

②

NAVAL POSTGRADUATE SCHOOL

Monterey, California

AD-A265 176



THESIS

Gallium Arsenide Dynamic Random Access Memory Support
Circuitry

by

Michael Andrew Morris

March 1993

Thesis Advisor:

Douglas J. Fouts

Approved for public release; distribution is unlimited.

93-12355



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION	UNCLASSIFIED		1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY				3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S)		5. MONITORING ORGANIZATION REPORT NUMBER(S)			
6a. NAME OF PERFORMING ORGANIZATION Naval Postgraduate School	6b. OFFICE SYMBOL (if applicable) EC	7a. NAME OF MONITORING ORGANIZATION Naval Postgraduate School			
6c. ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000		7b. ADDRESS (City, State, and ZIP Code) Monterey, CA 93943-5000			
8a. NAME OF FUNDING/SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (if applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER			
8c. ADDRESS (City, State, and ZIP Code)		10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. PROJECT NO. TASK NO. WORK UNIT ACCESSION NO.			
11. TITLE (Include Security Classification) GALLIUM ARSENIDE DYNAMIC RANDOM ACCESS MEMORY SUPPORT CIRCUITRY (U)					
12. PERSONAL AUTHOR(S) Morris, Michael Andrew					
13a. TYPE OF REPORT Master's Thesis	13b. TIME COVERED FROM 01/92 TO 03/93	14. DATE OF REPORT (Year, Month, Day) 1993, March, 27			15. PAGE COUNT 526
16. SUPPLEMENTARY NOTATION The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the United States Government.					
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) RAM, DRAM, Gallium Arsenide DRAM, Support Circuitry DRAM GaAs Logic Circuits, SBFL, DCFL, GaAs Layout, HSPICE, MAGIC			
19. ABSTRACT (Continue on reverse if necessary and identify by block number) This thesis presents the design and layout of a Gallium Arsenide (GaAs) Dynamic Random Access Memory (DRAM) array of eight four-bit words including refresh circuitry. In the last several years, there has been significant research investigating the possibilities of producing much faster, lower power and high density DRAM using GaAs. Thus far, this research has yielded success on a limited basis using special materials and fabrication techniques. This design, tested and simulated using HSPICE, supports a memory access time of approximately three nanoseconds, faster than present commercial Static Random Access Memory (SRAM). The logic circuits are designed using GaAs enhancement-mode and depletion-mode (E/D) metal semiconductor field-effect transistors (MESFETs). Charge storage is facilitated by a single GaAs MESFET connected to a parallel plate capacitor and the required minimum time between refresh is approximately three milliseconds. Power consumption is acceptable and fabrication by Vitesse Semiconductor Corporation using the HGaAs3 process is in progress. The design techniques, power consumption and timing are discussed and demonstrated for the basic logic circuits and the memory array read, write and refresh cycles. A significant increase in DRAM memory bandwidth is gained narrowing the memory bandwidth differential between primary memory and the processor.					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED		
22a. NAME OF RESPONSIBLE INDIVIDUAL Douglas J. Fouts			22b. TELEPHONE (Include Area Code) (408) 656-2852		22c. OFFICE SYMBOL EC/Fs

Approved for public release; distribution is unlimited

**GALLIUM ARSENIDE
DYNAMIC RANDOM ACCESS MEMORY
SUPPORT CIRCUITRY**

by
Michael Andrew Morris
Lieutenant, United States Navy
B.S.E.E., University of South Carolina, 1987

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

from the

NAVAL POSTGRADUATE SCHOOL
March 1993

Author:

Michael A. Morris

Michael Andrew Morris

Approved By:

Douglas J. Fouts

Douglas J. Fouts, Thesis Advisor

Herschel H. Loomis, Jr.

Herschel H. Loomis, Jr. Second Reader

Michael A. Morgan

Michael A. Morgan, Chairman,

Department of Electrical and Computer Engineering

Abstract

This thesis presents the design and layout of a Gallium Arsenide (GaAs) Dynamic Random Access Memory (DRAM) array of eight four-bit words including refresh circuitry. In the last several years, there has been significant research investigating the possibilities of producing much faster, lower power and high density DRAM using GaAs. Thus far, this research has yielded success on a limited basis using special materials and fabrication techniques. This design, tested and simulated using HSPICE, supports a memory access time of approximately three nanoseconds, faster than present commercial Static Random Access Memory (SRAM). The logic circuits are designed using GaAs enhancement-mode and depletion-mode (N/D) metal semiconductor field-effect transistors (MESFETs). Charge storage is facilitated by a single GaAs MESFET connected to a parallel plate capacitor and the required minimum time between refresh is approximately three milliseconds. Power consumption is acceptable and fabrication by Vitesse Semiconductor Corporation using the HGaAs3 process is in progress. The design techniques, power consumption and timing are discussed and demonstrated for the basic logic circuits and the memory array read, write and refresh cycles. A significant increase in DRAM memory bandwidth is gained narrowing the memory bandwidth differential between primary memory and the processor.

NTIS QUALITY INSPECTED 2

Accession For	
NTIS	<input checked="" type="checkbox"/>
DIA	<input type="checkbox"/>
University	<input type="checkbox"/>
JRC	<input type="checkbox"/>
By _____	
DRAFTED BY _____	
AVAILABILITY CODES	
REF ID: A_____	
FILE NUMBER _____	
P-1	

TABLE OF CONTENTS

I.	INTRODUCTION.....	1
A.	GALLIUM ARSENIDE (GaAs) DEVELOPMENT.....	1
B.	SILICON -VS- GALLIUM ARSENIDE.....	1
C.	GALLIUM ARSENIDE MEMORIES	2
II.	BASIC MEMORY DESIGN	4
A.	TYPES OF MEMORY	4
B.	BASIC DYNAMIC MEMORY OPERATIONS	4
III.	GALLIUM ARSENIDE LOGIC FAMILIES	7
A.	GALLIUM ARSENIDE DEPLETION-MODE LOGIC FAMILIES	7
1.	Unbuffered FET Logic (UBFL).....	7
2.	Buffered FET Logic (BFL)	8
3.	Schottky Diode FET Logic (SDFL).....	10
B.	GALLIUM ARSENIDE ENHANCEMENT-MODE LOGIC FAMILIES	11
1.	Direct-Coupled FET Logic (DCFL)	11
2.	Superbuffer FET Logic (SBFL).....	13
3.	Other GaAs E-mode Logic Families.....	14
IV.	GALLIUM ARSENIDE DRAM LOW-LEVEL CIRCUITS	15
A.	GaAs DRAM DCFL Logic Circuits	15
1.	DCFL Inverter (DINV)	15
2.	DCFL 2-Input NOR (D2NOR)	20
3.	DCFL 3-input NOR (D3NOR)	24
4.	DCFL 4-Input NOR Gate (D4NOR).....	29
5.	DCFL 2-input True NAND Gate (D2NAND)	33
6.	DCFL 2-input NAND Gate (DD2NAND).....	37
7.	DCFL 3-input NAND Gate (DD3NAND).....	41
8.	DCFL 2-input AND Gate (DD2AND).....	45
9.	DCFL 3-input AND Gate (DD3AND).....	49
10.	DCFL 4-input AND Gate (DD4AND).....	53
11.	DCFL 2-input OR Gate (DD2OR)	57
12.	DCFL 3-input OR Gate (DD3OR)	61
13.	DCFL 4-input OR Gate (DD4OR)	65
14.	"BIG" DCFL INVERTER (BDINV)	69
15.	DCFL LATCH (DLATCH)	73
16.	DCFL /Clear Data Flip-Flop (CPDFF)	77
B.	GaAs DRAM SBFL Logic Circuits.....	82
1.	SBFL Inverter (SINV)	82
2.	Super SBFL Inverter (SSINV)	86
3.	SBFL 2-input NOR Gate (S2NOR)	90

4.	SBFL 3-input NOR Gate (S3NOR)	94
5.	SBFL 4-input NOR Gate (S4NOR)	99
6.	SBFL 3-input OR Gate (S3OR)	104
7.	SBFL 2-input NAND Gate (SS2NAND)	108
8.	SBFL 4-input NAND Gate (SS4NAND)	112
9.	SBFL 3-input NAND Gate (SS3AND)	116
10.	SBFL 4-input NAND Gate (SS4AND)	120
11.	SBFL 2-input NOR Gate (BS2NOR)	124
12.	SBFL INVERTER (CSINV)	128
13.	SBFL 2-input NOR Gate (CSNOR)	132
C.	GaAs DRAM Mixed DCFL-SBFL Logic Circuits	136
1.	DCFL-SBFL 2-input AND Gate (BS2AND)	136
2.	SBFL-DCFL Data LATCH (SDLATCH)	140
3.	SBFL-DCFL Data Flip-Flop (SDFF)	145
4.	SBFL-DCFL DELAY Logic Element (DELAY)	149
5.	SBFL-DCFL Level Shifter Logic Element (LVL)	153
D.	SUMMARY	158
V.	GALLIUM ARSENIDE DRAM HIGH-LEVEL CIRCUITS	163
A.	Two-Phase Non-Overlapping Clock (CLOCK)	163
B.	One-of-Eight Decoder (DECODER)	166
C.	Eight Stage Counter (COUNTER)	171
D.	DRAM Refresh Circuitry (DREFRESH)	176
E.	Decoder Driver Circuit (DECODEDRVER)	186
F.	Output Logic Circuitry (OUTPUT)	195
G.	Operation Priority Logic Circuitry (WRITEP)	202
H.	Memory Busy Circuitry (MBSY)	206
I.	Data Ready Circuitry (DRDY)	208
J.	Write Logic Circuitry (WLOGIC)	210
K.	Pad Receiver Circuit (PADRCVR)	213
L.	Driver Pad Circuit (DRVRPAD)	214
M.	GaAs DRAM Array (RAM_ARRAY)	215
VI.	GALLIUM ARSENIDE DRAM	218
A.	Overall Block Diagram	218
B.	Layout Block Diagram	219
1.	INPUTS	220
2.	OUTPUTS	220
C.	Timing and Pad->Pad Simulation	221
1.	WRITE OPERATION	221
2.	READ OPERATION	227
3.	REFRESH OPERATION	235
D.	GaAs DRAM POWER CONSUMPTION	241
E.	SUMMARY OF GaAs DRAM MEMORY CHARACTERISTICS	243
1.	GaAs DRAM Minimum READ Operation	244

2. GaAs DRAM Minimum WRITE Operation	246
3. GaAs DRAM Minimum REFRESH Operation	249
VII. CONCLUSIONS	253
A. THE DESIGN CYCLE.....	253
1. Gallium Arsenide Circuit Design.....	253
2. Gallium Arsenide Circuit Simulation and Testing.....	254
3. Gallium Arsenide Layout and Testing	255
4. Gallium Arsenide Fabrication and Testing	255
B. CONCLUSIONS	256
1. Access Times	256
2. Power Consumption	257
3. Control Circuitry	257
APPENDIX A - HSPICE FILES	259
A. Listing File for DINV Transient Analysis at 25.0C	259
B. Listing File for D4NOR Transient Analysis @ 25.0C	262
C. Listing File for DD3NAND Transient Analysis @ 25.0C	265
D. Listing File for DD4AND Transient Analysis @ 25.0C	268
E. Listing File for DD4OR Transient Analysis @ 25.0C	271
F. Listing File for CPDFF Transient Analysis @ 25.0C	275
G. Listing File for DLATCH Transient Analysis @ 25.0C	279
H. Listing File for DELAY Transient Analysis @ 25.0C	283
I. Listing File for LVL Transient Analysis @ 25.0C	287
J. Listing File for CLOCK Transient Analysis @ 25.0C	290
K. Listing File for DECODER Transient Analysis @ 25.0C	297
L. Listing File for COUNTER Transient Analysis @ 25.0C	305
M. Listing File for DREFRESH Transient Analysis @ 25.0C	315
N. Listing File for DECODDRVER Transient Analysis @ 25.0C	333
O. Listing File for OUTPUT Transient Analysis @ 25.0C	357
P. Listing File for WRITEP Transient Analysis @ 25.0C	362
Q. Listing File for MBSY Transient Analysis @ 25.0C	366
R. Listing File for DRDY Transient Analysis @ 25.0C	370
S. Listing File for WLOGIC Transient Analysis @ 25.0C	373
T. GaAs DRAM HSPICE Pad->Pad Simulation	379
1. Run #1 LISTING FILE	379
2. Run #2 LISTING FILE (Abbreviated).....	487
3. Run #3 LISTING FILE (Abbreviated).....	489
4. Run #4 LISTING FILE (Abbreviated).....	491
U. Original HSPICE GaAs DRAM Source File.....	492
APPENDIX B - LAYOUT PLOT OF GaAs DRAM	509
BIBLIOGRAPHY	510
INITIAL DISTRIBUTION LIST	511

LIST OF FIGURES

Figure 2.1	General Block Diagram of A Dynamic Memory	5
Figure 3.1	Gallium Arsenide UBFL NOR Gate [Ref. 1:p. 6]	8
Figure 3.2	Gallium Arsenide UBFL NAND Gate [Ref. 1:p. 6]	8
Figure 3.3	Gallium Arsenide BFL NOR Gate [Ref. 1:p. 7]	9
Figure 3.4	Gallium Arsenide BFL NAND Gate [Ref. 1:p. 7]	9
Figure 3.5	Gallium Arsenide DTL NOR gate [Ref. 1:p. 8]	10
Figure 3.6	Gallium Arsenide DTL NAND gate [Ref. 1:p. 8]	11
Figure 3.7	Gallium Arsenide DCFL NOR gate [Ref. 1:p. 10]	12
Figure 3.8	Gallium Arsenide DCFL NAND gate [Ref. 1:p. 10]	12
Figure 3.9	Gallium Arsenide DCFL INVERTER gate [Ref. 1:p. 11]	13
Figure 3.10	Gallium Arsenide SBFL INVERTER gate [Ref. 10:p. 215]	13
Figure 3.11	Gallium Arsenide SBFL NOR gate [Ref. 10:p. 215]	14
Figure 4.1	Schematic and Logical Equivalence for DINV	16
Figure 4.2	DINV HSPICE Transient Analysis and Power Dissipation at 25.0C	17
Figure 4.3	DINV HSPICE Transient Analysis and Power Dissipation at 85.0C	18
Figure 4.4	DINV DC Transfer Curve at 25.0C	19
Figure 4.5	DINV DC Transfer Curve at 85.0C	20
Figure 4.6	D2NOR Schematic and Logical Equivalence	21
Figure 4.7	D2NOR HSPICE Transient Analysis and Power Dissipation at 25.0C	21
Figure 4.8	D2NOR HSPICE Transient Analysis and Power Dissipation at 85.0C	22
Figure 4.9	D2NOR DC Transfer Curve at 25.0C	23
Figure 4.10	D2NOR DC Transfer Curve at 85.0C	24
Figure 4.11	D3NOR Schematic and Logical Equivalence	25
Figure 4.12	D3NOR HSPICE Transient Analysis and Power Dissipation at 25.0C	26
Figure 4.13	D3NOR HSPICE Transient Analysis and Power Dissipation at 85.0C	27
Figure 4.14	D3NOR DC Transfer Curve at 25.0C	28
Figure 4.15	D3NOR DC Transfer Curve at 85.0C	29
Figure 4.16	D4NOR Schematic and Logical Equivalence	30
Figure 4.17	D4NOR HSPICE Transient Analysis and Power Dissipation at 25.0C	30
Figure 4.18	D4NOR HSPICE Transient Analysis and Power Dissipation at 85.0C	31
Figure 4.19	D4NOR DC Transfer Curve at 25.0C	32
Figure 4.20	D4NOR DC Transfer Curve at 85.0C	33
Figure 4.21	D2NAND Schematic and Logical Equivalence	34
Figure 4.22	D2NAND HSPICE Transient Analysis and Power Dissipation at 25.0C	34
Figure 4.23	D2NAND HSPICE Transient Analysis and Power Dissipation at 85.0C	35
Figure 4.24	D2NAND DC Transfer Curve at 25.0C	36
Figure 4.25	D2NAND DC Transfer Curve at 85.0C	37
Figure 4.26	DD2NAND Schematic and Logical Equivalence	37
Figure 4.27	DD2NAND HSPICE Transient Analysis and Power Dissipation at 25.0C	38
Figure 4.28	DD2NAND HSPICE Transient Analysis and Power Dissipation at 85.0C	39
Figure 4.29	DD2NAND DC Transfer Curve at 25.0C	40
Figure 4.30	DD2NAND DC Transfer Curve at 85.0C	41
Figure 4.31	DD3NAND Schematic and Logical Equivalence	41
Figure 4.32	DD3NAND HSPICE Transient Analysis and Power Dissipation at 25.0C	42
Figure 4.33	DD3NAND HSPICE Transient Analysis and Power Dissipation at 85.0C	43

Figure 4.34	DD3NAND DC Transfer Curve at 25.0C	44
Figure 4.35	DD3NAND DC Transfer Curve at 85.0C	45
Figure 4.36	DD2AND Schematic and Logical Equivalence	45
Figure 4.37	DD2AND HSPICE Transient Analysis and Power Dissipation at 25.0C	46
Figure 4.38	DD2AND HSPICE Transient Analysis and Power Dissipation at 85.0C	47
Figure 4.39	DD2AND DC Transfer Curve at 25.0C	48
Figure 4.40	DD2AND DC Transfer Curve at 85.0C	49
Figure 4.41	DD3AND Schematic and Logical Equivalence	49
Figure 4.42	DD3AND HSPICE Transient Analysis and Power Dissipation at 25.0C	50
Figure 4.43	DD3AND HSPICE Transient Analysis and Power Dissipation at 85.0C	51
Figure 4.44	DD3AND DC Transfer Curve at 25.0C	52
Figure 4.45	DD3AND DC Transfer Curve at 85.0C	53
Figure 4.46	DD4AND Schematic and Logical Equivalence	54
Figure 4.47	DD4AND HSPICE Transient Analysis and Power Dissipation at 25.0C	54
Figure 4.48	DD4AND HSPICE Transient Analysis and Power Dissipation at 85.0C	55
Figure 4.49	DD4AND DC Transfer Curve at 25.0C	56
Figure 4.50	DD4AND DC Transfer Curve at 85.0C	57
Figure 4.51	DD2OR Schematic And Logical Equivalence	57
Figure 4.52	DD2OR HSPICE Transient Analysis and Power Dissipation at 25.0C	58
Figure 4.53	DD2OR HSPICE Transient Analysis and Power Dissipation at 85.0C	59
Figure 4.54	DD2OR DC Transfer Curve at 25.0C	60
Figure 4.55	DD2OR DC Transfer Curve at 85.0C	61
Figure 4.56	DD3OR Schematic And Logical Equivalence	61
Figure 4.57	DD3OR HSPICE Transient Analysis and Power Dissipation at 25.0C	62
Figure 4.58	DD3OR HSPICE Transient Analysis and Power Dissipation at 85.0C	63
Figure 4.59	DD3OR DC Transfer Curve at 25.0C	64
Figure 4.60	DD3OR DC Transfer Curve at 85.0C	65
Figure 4.61	DD4OR Schematic And Logical Equivalence	65
Figure 4.62	DD4OR HSPICE Transient Analysis and Power Dissipation at 25.0C	66
Figure 4.63	DD4OR HSPICE Transient Analysis and Power Dissipation at 85.0C	67
Figure 4.64	DD4OR DC Transfer Curve at 25.0C	68
Figure 4.65	DD4OR DC Transfer Curve at 85.0C	69
Figure 4.66	BDINV Schematic And Logical Equivalence	69
Figure 4.67	BDINV HSPICE Transient Analysis and Power Dissipation at 25.0C	70
Figure 4.68	BDINV HSPICE Transient Analysis and Power Dissipation at 85.0C	71
Figure 4.69	BDINV DC Transfer Curve at 25.0C	72
Figure 4.70	BDINV DC Transfer Curve at 85.0C	73
Figure 4.71	DLATCH Schematic And Logical Equivalence	73
Figure 4.72	DLATCH HSPICE Transient Analysis and Power Dissipation at 25.0C	74
Figure 4.73	DLATCH HSPICE Transient Analysis and Power Dissipation at 85.0C	75
Figure 4.74	DLATCH DC Transfer Curve at 25.0C	76
Figure 4.75	DLATCH DC Transfer Curve at 85.0C	77
Figure 4.76	CPDFF Schematic And Logical Equivalence	78
Figure 4.77	CPDFF HSPICE Transient Analysis and Power Dissipation at 25.0C	79
Figure 4.78	CPDFF HSPICE Transient Analysis and Power Dissipation at 85.0C	80
Figure 4.79	CPDFF DC Transfer Curve at 25.0C	81
Figure 4.80	CPDFF DC Transfer Curve at 85.0C	82
Figure 4.81	Schematic and Logical Equivalence for SINV	83
Figure 4.82	SINV HSPICE Transient Analysis and Power Dissipation at 25.0C	83
Figure 4.83	SINV HSPICE Transient Analysis and Power Dissipation at 85.0C	84
Figure 4.84	SINV DC Transfer Curve at 25.0C	85

Figure 4.85	SINV DC Transfer Curve at 85.0C	86
Figure 4.86	Schematic and Logical Equivalence for SSINV	87
Figure 4.87	SSINV HSPICE Transient Analysis and Power Dissipation at 25.0C	87
Figure 4.88	SSINV HSPICE Transient Analysis and Power Dissipation at 85.0C	88
Figure 4.89	SSINV DC Transfer Curve at 25.0C	89
Figure 4.90	SSINV DC Transfer Curve at 85.0C	90
Figure 4.91	Schematic and Logical Equivalence for S2NOR	91
Figure 4.92	S2NOR HSPICE Transient Analysis and Power Dissipation at 25.0C	91
Figure 4.93	S2NOR HSPICE Transient Analysis and Power Dissipation at 85.0C	92
Figure 4.94	S2NOR DC Transfer Curve at 25.0C	93
Figure 4.95	S2NOR DC Transfer Curve at 85.0C	94
Figure 4.96	Schematic and Logical Equivalence for S3NOR	95
Figure 4.97	S3NOR HSPICE Transient Analysis and Power Dissipation at 25.0C	96
Figure 4.98	S3NOR HSPICE Transient Analysis and Power Dissipation at 85.0C	97
Figure 4.99	S3NOR DC Transfer Curve at 25.0C	98
Figure 4.100	S3NOR DC Transfer Curve at 85.0C	99
Figure 4.101	Schematic and Logical Equivalence for S4NOR	100
Figure 4.102	S4NOR HSPICE Transient Analysis and Power Dissipation at 25.0C	101
Figure 4.103	S4NOR HSPICE Transient Analysis and Power Dissipation at 85.0C	102
Figure 4.104	S4NOR DC Transfer Curve at 25.0C	103
Figure 4.105	S4NOR DC Transfer Curve at 85.0C	104
Figure 4.106	Schematic and Logical Equivalence for S3OR	104
Figure 4.107	S3OR HSPICE Transient Analysis and Power Dissipation at 25.0C	105
Figure 4.108	S3OR HSPICE Transient Analysis and Power Dissipation at 85.0C	106
Figure 4.109	S3OR DC Transfer Curve at 25.0C	107
Figure 4.110	S3OR DC Transfer Curve at 85.0C	108
Figure 4.111	Schematic and Logical Equivalence for SS2NAND	108
Figure 4.112	SS2NAND HSPICE Transient Analysis and Power Dissipation at 25.0C	109
Figure 4.113	SS2NAND HSPICE Transient Analysis and Power Dissipation at 85.0C	110
Figure 4.114	SS2NAND DC Transfer Curve at 25.0C	111
Figure 4.115	SS2NAND DC Transfer Curve at 85.0C	112
Figure 4.116	Schematic and Logical Equivalence for SS4NAND	113
Figure 4.117	SS4NAND HSPICE Transient Analysis and Power Dissipation at 25.0C	113
Figure 4.118	SS4NAND HSPICE Transient Analysis and Power Dissipation at 85.0C	114
Figure 4.119	SS4NAND DC Transfer Curve at 25.0C	115
Figure 4.120	SS4NAND DC Transfer Curve at 85.0C	116
Figure 4.121	Schematic and Logical Equivalence for SS3AND	116
Figure 4.122	SS3AND HSPICE Transient Analysis and Power Dissipation at 25.0C	117
Figure 4.123	SS3AND HSPICE Transient Analysis and Power Dissipation at 85.0C	118
Figure 4.124	SS3AND DC Transfer Curve at 25.0C	119
Figure 4.125	SS3AND DC Transfer Curve at 85.0C	120
Figure 4.126	Schematic and Logical Equivalence for SS4AND	121
Figure 4.127	SS4AND HSPICE Transient Analysis and Power Dissipation at 25.0C	121
Figure 4.128	SS4AND HSPICE Transient Analysis and Power Dissipation at 85.0C	122
Figure 4.129	SS4AND DC Transfer Curve at 25.0C	123
Figure 4.130	SS4AND DC Transfer Curve at 85.0C	124
Figure 4.131	Schematic and Logical Equivalence for BS2NOR	125
Figure 4.132	BS2NOR HSPICE Transient Analysis and Power Dissipation at 25.0C	125
Figure 4.133	BS2NOR HSPICE Transient Analysis and Power Dissipation at 85.0C	126
Figure 4.134	BS2NOR DC Transfer Curve at 25.0C	127
Figure 4.135	BS2NOR DC Transfer Curve at 85.0C	128

Figure 4.136	Schematic and Logical Equivalence for CSINV	129
Figure 4.137	CSINV HSPICE Transient Analysis and Power Dissipation at 25.0C	129
Figure 4.138	CSINV HSPICE Transient Analysis and Power Dissipation at 85.0C	130
Figure 4.139	CSINV DC Transfer Curve at 25.0C	131
Figure 4.140	CSINV DC Transfer Curve at 85.0C	132
Figure 4.141	Schematic and Logical Equivalence for CSNOR	133
Figure 4.142	CSNOR HSPICE Transient Analysis and Power Dissipation at 25.0C	133
Figure 4.143	CSNOR HSPICE Transient Analysis and Power Dissipation at 85.0C	134
Figure 4.144	CSNOR DC Transfer Curve at 25.0C	135
Figure 4.145	CSNOR DC Transfer Curve at 85.0C	136
Figure 4.146	Schematic and Logical Equivalence for BS2AND	137
Figure 4.147	BS2AND HSPICE Transient Analysis and Power Dissipation at 25.0C	137
Figure 4.148	BS2AND HSPICE Transient Analysis and Power Dissipation at 85.0C	138
Figure 4.149	BS2AND DC Transfer Curve at 25.0C	139
Figure 4.150	BS2AND DC Transfer Curve at 85.0C	140
Figure 4.151	Schematic and Logical Equivalence for SDLATCH	141
Figure 4.152	SDLATCH HSPICE Transient Analysis and Power Dissipation at 25.0C	142
Figure 4.153	SDLATCH HSPICE Transient Analysis and Power Dissipation at 85.0C	143
Figure 4.154	SDLATCH DC Transfer Curve at 25.0C	144
Figure 4.155	SDLATCH DC Transfer Curve at 85.0C	145
Figure 4.156	Schematic and Logical Equivalence for SDFF	145
Figure 4.157	SDFF HSPICE Transient Analysis and Power Dissipation at 25.0C	146
Figure 4.158	SDFF HSPICE Transient Analysis and Power Dissipation at 85.0C	147
Figure 4.159	SDFF DC Transfer Curve at 25.0C	148
Figure 4.160	SDFF DC Transfer Curve at 85.0C	149
Figure 4.161	Schematic and Logical Equivalence for DELAY	149
Figure 4.162	DELAY HSPICE Transient Analysis and Power Dissipation at 25.0C	150
Figure 4.163	DELAY HSPICE Transient Analysis and Power Dissipation at 85.0C	151
Figure 4.164	DELAY DC Transfer Curve at 25.0C	152
Figure 4.165	DELAY DC Transfer Curve at 85.0C	153
Figure 4.166	Schematic and Logical Equivalence for LVL	154
Figure 4.167	LVL HSPICE Transient Analysis and Power Dissipation at 25.0C	155
Figure 4.168	LVL HSPICE Transient Analysis and Power Dissipation at 85.0C	156
Figure 4.169	LVL DC Transfer Curve at 25.0C	157
Figure 4.170	LVL DC Transfer Curve at 85.0C	158
Figure 5.1	Schematic and Logical Equivalence for CLOCK	164
Figure 5.2	CLOCK HSPICE Transient Analysis and Power Dissipation at 25.0C	165
Figure 5.3	CLOCK HSPICE Transient Analysis and Power Dissipation at 85.0C	166
Figure 5.4	DECODER Schematic and Logical Equivalence	167
Figure 5.5	DECODER HSPICE Transient Analysis (Part One) at 25.0C	168
Figure 5.6	DECODER HSPICE Transient Analysis (Part Two) at 25.0C	169
Figure 5.7	DECODER HSPICE Transient Analysis (Part One) at 85.0C	170
Figure 5.8	DECODER HSPICE Transient Analysis (Part Two) at 85.0C	171
Figure 5.9	COUNTER Schematic and Logical Equivalence	172
Figure 5.10	COUNTER HSPICE Transient Analysis (Part One) at 25.0C	173
Figure 5.11	COUNTER HSPICE Transient Analysis (Part Two) & Power at 25.0C	174
Figure 5.12	COUNTER HSPICE Transient Analysis (Part One) at 85.0C	175
Figure 5.13	COUNTER HSPICE Transient Analysis (Part Two) & Power at 85.0C	176
Figure 5.14	DREFRESH Schematic and Logical Equivalence	177
Figure 5.15	DREFRESH HSPICE Transient Analysis (Part One) at 25.0C	179
Figure 5.16	DREFRESH HSPICE Transient Analysis (Part Two) at 25.0C	180

Figure 5.17	DREFRESH HSPICE Transient Analysis (Part Three) at 25.0C	181
Figure 5.18	DREFRESH HSPICE POWER at 25.0C	182
Figure 5.19	DREFRESH HSPICE Transient Analysis (Part One) at 85.0C	183
Figure 5.20	DREFRESH HSPICE Transient Analysis (Part Two) at 85.0C	184
Figure 5.21	DREFRESH HSPICE Transient Analysis (Part Three) at 85.0C	185
Figure 5.22	DREFRESH HSPICE POWER at 85.0C	186
Figure 5.23	DECODDRVER Schematic and Logical Equivalence	187
Figure 5.24	DECODDRVER HSPICE Transient Analysis (Part One) at 25.0C	188
Figure 5.25	DECODDRVER HSPICE Transient Analysis (Part Two) at 25.0C	189
Figure 5.26	DECODDRVER HSPICE Transient Analysis (Part Three) at 25.0C	190
Figure 5.27	DECODDRVER HSPICE POWER at 25.0C	191
Figure 5.28	DECODDRVER HSPICE Transient Analysis (Part One) at 85.0C	192
Figure 5.29	DECODDRVER HSPICE Transient Analysis (Part Two) at 85.0C	193
Figure 5.30	DECODDRVER HSPICE Transient Analysis (Part Three) at 85.0C	194
Figure 5.31	DECODDRVER HSPICE POWER at 85.0C	195
Figure 5.32	OUTPUT Schematic and Logical Equivalence	196
Figure 5.33	OUTPUT HSPICE Transient Analysis (Part One) at 25.0C	197
Figure 5.34	OUTPUT HSPICE Transient Analysis (Part Two) at 25.0C	198
Figure 5.35	OUTPUT HSPICE POWER at 25.0C	199
Figure 5.36	OUTPUT HSPICE Transient Analysis (Part One) at 85.0C	200
Figure 5.37	OUTPUT HSPICE Transient Analysis (Part Two) at 85.0C	201
Figure 5.38	OUTPUT HSPICE POWER at 85.0C	202
Figure 5.39	WRITEP Schematic and Logical Equivalence	203
Figure 5.40	WRITEP HSPICE Transient Analysis at 25.0C	203
Figure 5.41	WRITEP HSPICE POWER at 25.0C	204
Figure 5.42	WRITEP HSPICE Transient Analysis at 85.0C	205
Figure 5.43	WRITEP HSPICE POWER at 85.0C	206
Figure 5.44	MBSY Schematic and Logical Equivalence	207
Figure 5.45	MBSY HSPICE Transient Analysis & Power at 25.0C	207
Figure 5.46	MBSY HSPICE Transient Analysis & Power at 85.0C	208
Figure 5.47	DRDY Schematic and Logical Equivalence	209
Figure 5.48	DRDY HSPICE Transient Analysis & Power at 25.0C	209
Figure 5.49	DRDY HSPICE Transient Analysis & Power at 85.0C	210
Figure 5.50	WLOGIC Schematic and Logical Equivalence	211
Figure 5.51	WLOGIC HSPICE Transient Analysis & Power at 25.0C	212
Figure 5.52	WLOGIC HSPICE Transient Analysis & Power at 85.0C	213
Figure 5.53	PADRCVR Schematic and Logical Equivalence	214
Figure 5.54	DRVRPAD Schematic and Logical Equivalence	215
Figure 5.55	RAM_ARRAY Block Diagram	216
Figure 6.1	GaAs DRAM Overall Logic Block Diagram	218
Figure 6.2	GaAs DRAM Layout Block Diagram 219	
Figure 6.3	GaAs DRAM WRITE Operation at 25.0C (Part One)	222
Figure 6.4	GaAs DRAM WRITE Operation at 25.0C (Part Two)	223
Figure 6.5	GaAs DRAM WRITE Operation at 25.0C (Part Three)	224
Figure 6.6	GaAs DRAM WRITE Operation at 85.0C (Part One)	225
Figure 6.7	GaAs DRAM WRITE Operation at 85.0C (Part Two)	226
Figure 6.8	GaAs DRAM WRITE Operation at 85.0C (Part Three)	227
Figure 6.9	GaAs DRAM READ Operation at 25.0C (Part One)	228
Figure 6.10	GaAs DRAM READ Operation at 25.0C (Part Two)	229
Figure 6.11	GaAs DRAM READ Operation at 25.0C (Part Three)	230
Figure 6.12	GaAs DRAM READ Operation at 25.0C (Part Four)	231

Figure 6.13	GaAs DRAM READ Operation at 85.0C (Part One)	232
Figure 6.14	GaAs DRAM READ Operation at 85.0C (Part Two)	233
Figure 6.15	GaAs DRAM READ Operation at 85.0C (Part Three)	234
Figure 6.16	GaAs DRAM READ Operation at 85.0C (Part Four)	235
Figure 6.17	GaAs DRAM REFRESH Operation at 25.0C (Part One)	236
Figure 6.18	GaAs DRAM REFRESH Operation at 25.0C (Part Two)	237
Figure 6.19	GaAs DRAM REFRESH Operation at 25.0C (Part Three)	238
Figure 6.20	GaAs DRAM REFRESH Operation at 85.0C (Part One)	239
Figure 6.21	GaAs DRAM REFRESH Operation at 85.0C (Part Two)	240
Figure 6.22	GaAs DRAM REFRESH Operation at 85.0C (Part Three)	241
Figure 6.23	GaAs DRAM Memory Array Power Consumption @25.0C	242
Figure 6.24	GaAs DRAM Memory Array Power Consumption @85.0C	243
Figure 6.25	GaAs DRAM Minimum READ Operation: Transient Analysis (Part One)	244
Figure 6.26	GaAs DRAM Minimum READ Operation: Transient Analysis (Part Two)	245
Figure 6.27	GaAs DRAM Minimum READ Operation: Transient Analysis (Part Three)	246
Figure 6.28	GaAs DRAM Minimum WRITE Operation: Transient Analysis (Part One)	247
Figure 6.29	GaAs DRAM Minimum WRITE Operation: Transient Analysis (Part Two)	248
Figure 6.30	GaAs DRAM Minimum WRITE Operation: Transient Analysis (Part Three)	249
Figure 6.31	GaAs DRAM Minimum REFRESH Operation: Transient Analysis (Part One)	250
Figure 6.32	GaAs DRAM Minimum REFRESH Operation: Transient Analysis (Part Two)	251
Figure 6.33	GaAs DRAM Minimum REFRESH Operation: Transient Analysis (Part Three)	252

ACKNOWLEDGEMENTS

To Kathy, my wife: Your support, dedication and love throughout the last two and one half years has made this all possible. Thank you.

To my thesis advisor Dr. Douglas J. Fouts: Your vision, engineering expertise, unflagging confidence and perpetual enthusiasm served me well during my tenure. Thank you.

To my friend and associate Lieutenant Commander Christopher B. Vagts: Without your perseverance, expertise and previous work, this never would have happened. Thank you, and I wish for you "Fair Winds and Following Seas".

A special thanks to the Naval Postgraduate School ECE Department computer staff, especially Bob Limes, for their outstanding support service.

Out in the real world, a very special mention to the product support division of Framemaker (What a great product!) without whose help this thesis would not have made it, particularly when importing all these graphics.

Additionally, Meta Software, the HSPICE company deserves mega kudos for the product support provided to NPS.

Finally, thanks to my good friend, Lt. Charlie Victory, whose work ethic and enthusiasm made the thesis experience much more endurable.

I. INTRODUCTION

A. GALLIUM ARSENIDE (GaAs) DEVELOPMENT

Commercially, GaAs has been in use as a semiconductor since the 1960's, specifically in the fields of microwaves and optics. The speed offered by GaAs integrated circuits is its major drawing point. In the embryonic stages of GaAs integrated circuit (IC) development, low density devices such as microwave/optical transmitters and receivers were considered breakthroughs. On the other hand, silicon (Si) ICs have been widely researched and tremendous density gains have been achieved. Examples of these gains are the 64 megabit DRAM chip and the Intel processor 80486. Conversely, GaAs IC research, development and fabrication processes are at least one generation behind. There are several reasons for this, the first and foremost is cost. Millions of dollars are required to "tool up" to fabricate ICs. While Si ICs are in tremendous worldwide demand with many large companies manufacturing a multitude of Si digital ICs, presently there is no such demand for GaAs. Until the demand increases, a limited number of smaller companies will continue research, development, testing and production of a small number of GaAs ICs using fabrication equipment from the last generation of Si processes. Additionally, as when Si development was in its early stages, there are several different GaAs fabrication processes being used, each has its own advantages, and some manufacturers may be "sitting out", waiting for a single process to become predominant.

B. SILICON -VS- GALLIUM ARSENIDE

Speed coupled with lower power consumption is the main issue when comparing Si to GaAs. Circuits that must operate at high-speeds use much less power when produced from GaAs than Si. The Power-Delay Product (power dissipated \times propagation delay) when used to compare GaAs to Si, yields GaAs a 5:1 advantage. Additionally, circuits subject to radiation (such as in space satellites) suffer two results, Single Event Upsets (SEU's) and substrate degradation. GaAs ICs are subject to SEUs but do not suffer from substrate degradation. Logic gate propagation delays for GaAs digital ICs are on the order of 10-150 picoseconds, whereas Si offers gate delays in nanoseconds. [Ref. 1:p. 3].

However, there are disadvantages to GaAs digital IC fabrication. First, the present density of the commercially available GaAs ICs is much less than those produced in Si. Some of the reasons this is so were discussed above. Second, electrical signals traverse a glass epoxy circuit board at the rate of approximately

one foot per nanosecond, but the same electrical signal will traverse a GaAs logic gate in as few as 10 picoseconds yielding a large ratio of input/output delay-to-propagation delay. Because of the very high speeds offered by GaAs ICs, transmission line theory must be considered and utilized when designing in GaAs. Third, the layout of a Si CMOS gate (pull-up to pull-down) is very symmetric (this is because it is a complementary logic design using an *n*-type transistor and a *p*-type transistor. However, a GaAs MESFET inverter uses a much smaller pull-up than pull-down (both *n*-channel FETs, hence not a complementary logic design) and this yields very asymmetric geometries which complicate the layout and yield lower IC densities. Fourth, while the cost to produce GaAs ICs has fallen significantly in the last year such that GaAs ICs (in quantity) now cost less than comparable Emitter-Coupled Logic (ECL) or Bipolar Complementary Metal-Oxide Semiconductor (BiCMOS), fabrication of GaAs ICs is still expensive. However, should the trend towards lower costs continue, the cost of GaAs IC's will soon be comparable to Si for most circuits. Fifth, layout and circuit simulation tools for Si have evolved through several generations whereas the like tools for GaAs are sparse but improving steadily. Sixth, the voltage gain of GaAs MESFETs is small (this is imposed by the Schottky barrier junction gate of the MESFET which exhibits a forward voltage conduction limit of about 0.7 volts positive with respect to the source), consequently the noise margin for *n*-channel GaAs digital logic circuits is also small. The magnitude of the noise margin varies somewhat with which GaAs logic family is used. Finally, GaAs suffers from leakage currents not affecting Si. These GaAs leakage currents impact heavily on the design of GaAs circuits which use charge storage. [Ref. 1].

C. GALLIUM ARSENIDE MEMORIES

Considerable GaAs research within academe and, to a lesser extent within industry, has occurred and the results are encouraging. Within the field of GaAs memories, the late 1980's have yielded several low density GaAs static memories (SRAM's) [Ref. 2][Ref. 3] and at least four hybrid metal, dynamic memories [Ref. 4], [Ref. 5], [Ref. 6], and [Ref. 7]. To date, there have been no reports of a successful GaAs DRAM design which used standard GaAs materials and fabrication techniques.

Presently available commercial Si DRAMs offer access times on the order of 60 nanoseconds while commercial Si SRAMs have access times of approximately 10 nanoseconds. But static memory integrated circuits offer much lower densities by virtue of the fact that one data bit of static memory requires four to six transistors whereas one data bit of dynamic memory may be represented by a single transistor in a dynamic memory. This is because static memories use a flip-flop configuration of transistors as the basic storage element while dynamic memories use charge storing capacitors as the basic storage element. Additionally,

SRAMs, by virtue of their flip-flop design, use significantly more power per bit. For a thorough discussion of the charge storage aspects of this thesis, see the work by Vagts [Ref. 8].

This thesis will present some of the Gallium Arsenide logic families, basic designs of GaAs logic gates built into GaAs logic circuits, and then focus on the final product, a GaAs DRAM. The topics covered will include basic memory design, testing via HSPICE simulation, discussion of the layout using MAGIC (with GaAs technology files), overall timing diagrams, and finally, conclusions.

II. BASIC MEMORY DESIGN

A. TYPES OF MEMORY

Static memory retains its data anytime that power is applied because of the previously mentioned flip-flop. Dynamic memory, on the other hand, relies on the charge storage of a capacitor (generally) connected to a pass transistor. Both types of memories will lose their data once power is removed. However, maintaining the dynamic memory data, even with power on, requires periodic "recharging" of the capacitor in an operation called refresh. A discussion of the read-only memories (ROM) and its derivatives is beyond the scope of this thesis.

The type of memory being discussed here is referred to as "read-write" memory. It is incorrectly called "random access memory" in place of "read-write" memory probably resulting from the "old" days when certain types of memories could not be accessed randomly (meaning the control logic could not obtain the contents of the desired address in memory without passing by other addresses before it or after it). As an example, magnetic tapes provide a type of memory that may only be accessed "sequentially". This label "random access memory" is the second part of the present commonly used abbreviation DRAM.

B. BASIC DYNAMIC MEMORY OPERATIONS

There are only three basic memory operations: read, write and refresh that will be discussed in this report. The discussion that follows generally relates to both the operation of "generic" memories and the operation of the topic memory.

Referring to Figure 2.1 on page 5, which is both a representation of a generic DRAM and the representation of the topic DRAM, one may see where the external inputs signals are applied and also the origin of the output signals.

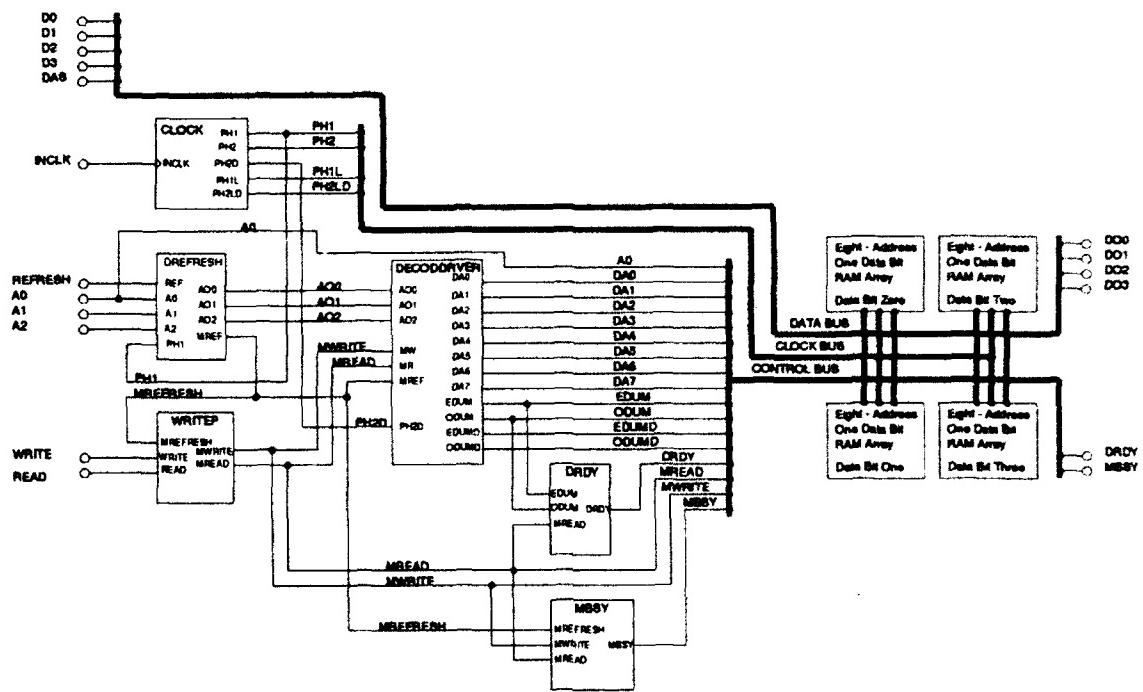


Figure 2.1 General Block Diagram of A Dynamic Memory

Reading the memory is accomplished by checking the status of the "memory busy" (MBSY) signal, presenting the memory control logic with the address of the desired location, pulsing the read line, latching the contents of the desired memory location, and setting the "data ready" (DRDY) signal. The memory busy signal tells the external users of the memory array that memory is presently unavailable and is asserted when the memory array is either busy accomplishing a read, write or a refresh operation. The strobe pulse on the read signal line instructs the control logic to commence the read operation and to assert the memory busy signal. Once the data is obtained from the desired memory location, it is latched into the output data latches, the data ready is asserted and memory busy signals is de-asserted. These signals indicates to the present external user that the requested data is ready and waiting on the memory output data lines. Additionally, the de-assertion of the memory busy signal indicate that the memory array is once again ready for further tasking.

Writing the memory is accomplished is a similar but slightly different manner. Writing requires data so the first step (given the correct status of the memory busy signal) is the present valid data and assert the "data strobe" (DAS) signal. This signal, asserted by the external user of the memory, indicates to the memory control logic that the data now present on the input data lines is stable, valid and ready to be latched. The

control logic then acts to latch the input data and will assert the memory busy signal. Once the input data is latched, this frees the external memory user to use the bus (or busses) for other business. Next (or simultaneous to the presentation of the input data), the external memory user presents the address of the target memory location and asserts the memory write signal. This signal directs the memory control logic to transfer the data (already latched or latched simultaneously) to the target memory location. Once the memory array control logic has completed the write operation, it will de-assert the memory busy signal.

As the subject memory is dynamic, the stored charge will eventually leak or diminish and requires that it be periodically recharged. This is accomplished by the third memory operation, refresh. The refresh operation is executed regularly on a schedule dictated by the physics of the particular DRAM. Commercial DRAMs accomplish the refresh operation approximately every three - five milliseconds and the refresh operation requires approximately 300 nanoseconds [Ref. 9:p. 648]. The topic GaAs DRAM requires refresh at a minimum interval of approximately 3 milliseconds. The refresh operation basically consists of sequential reading then writing of (all data bits) each address in the memory array. It is not required that it be sequential, it happens to be easier to design the refresh controller logic to operate sequentially. The topic GaAs DRAM, by virtue of its particular sense amplifier design, only requires that the addresses be read in order to be refreshed, not read then written. For a more thorough discussion of the sense amplifier and the topic GaAs DRAM refresh operation, see the work of Vagts [Ref. 8:pp. 10-21].

III. GALLIUM ARSENIDE LOGIC FAMILIES

This discussion of GaAs logic families will be restricted to *n*-channel GaAs MESFETs, both enhancement-mode (e-mode) and depletion-mode (d-mode). There exists a *p*-channel GaAs MESFET but it is not widely used because it requires a high electric field to obtain the necessary saturated velocity of holes in GaAs [Ref. 10:p. 195]. For an excellent discussion of the available GaAs logic families, see [Ref. 10:pp. 195-244].

A. GALLIUM ARSENIDE DEPLETION-MODE LOGIC FAMILIES

The Gallium Arsenide depletion-mode logic families use both depletion-mode (normally-on) MESFETs and level-shifters, usually formed of forward-biased Schottky diodes. The level-shifters are required because the logic circuits in these families are characterized by unequal input/output voltage levels. This arises because V_{GS} must be made negative in order to turn off the depletion-mode MESFET, but V_{DS} must remain positive at all times. Additionally, two power supplies are required in order to provide both positive and negative signals. These power supplies, positive V_{DD} (also referred to as V_{DS}) and negative V_{SS} , result in additional power dissipated in the circuit. However, in defense on the GaAs depletion-mode logic families, larger logic voltage swings may be obtained using depletion-mode GaAs MESFETs which results in better (larger) noise margins.

1. Unbuffered FET Logic (UBFL)

This form of GaAs logic circuit offers reasonably low power dissipation, high noise margins, fairly low propagation delays for low fanout only. However, UBFL requires excessive chip real estate as a single UBFL 2-input NOR gate requires five d-mode MESFETs and two Schottky diodes, see Figure 3.1 on page 8. For an example of a UBFL NAND gate, see Figure 3.2 on page 8.

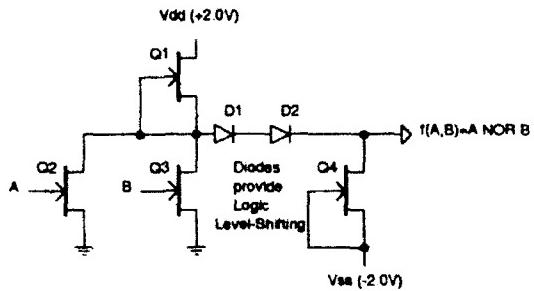


Figure 3.1 Gallium Arsenide UBFL NOR Gate [Ref. 1:p. 6]

The UBFL NAND gate structure is very similar to that of the UBFL NOR, the primary difference is the logic-determining d-mode MESFETs (Q2 & Q3) are in series vice parallel. This serves to limit the functionality in reality to a two input gate because anymore than two series MESFETs will prevent the individual MESFETs from acting upon their inputs. This is because the input pin action is relative to the source or drain voltage and for series transistors it varies. For the above reasons, one designs GaAs logic gates using almost exclusively NORs as the building blocks and applies the DeMorgan's theorems [Ref. 9:pp. 154-155] to yield the other desired logic elements. For an example of a true UBFL NAND gate, see Figure 3.2 on page 8.

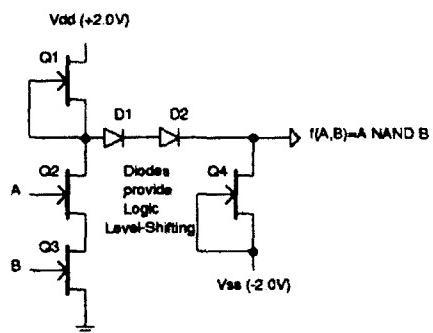


Figure 3.2 Gallium Arsenide UBFL NAND Gate [Ref. 1:p. 6]

2. Buffered FET Logic (BFL)

One possible solution to cure the poor fanout offered by UBFL is to couple a UBFL logic circuit with a source-follower stage. This works well to proportionally decrease the propagation delay as the fanout is increased but requires the use of two, active load, d-mode MESFETs which increases the amount of power

dissipated by the circuit. In addition, depending on the transistor sizes used, there is little savings in chip real estate. For an example of a BFL NOR gate, see Figure 3.3 on page 9.

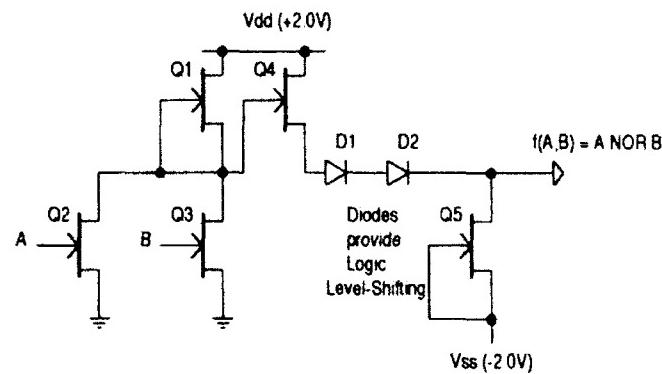


Figure 3.3 Gallium Arsenide BFL NOR Gate [Ref. 1:p. 7]

Examining Figure 3.3, the aforementioned source-follower stage is comprised of transistors Q4 and Q5. The diodes D1 and D2 again provide logic level-shifting. The additional power requirements of BFL arise from the addition of the source-follower stage direct current path from V_{DD} to V_{SS}. For an example of a true BFL NAND gate, see Figure 3.4 on page 9.

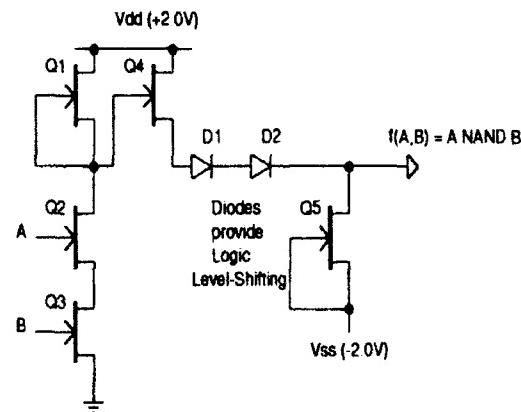


Figure 3.4 Gallium Arsenide BFL NAND Gate [Ref. 1:p. 7]

3. Schottky Diode FET Logic (SDFL)

Thus far in the discussion of GaAs logic families or circuits, the desired logic function has been performed by GaAs MESFETs. The NOR function is accomplished by MESFETs in parallel, the NAND function, series MESFETs, and more complex functions, a combination of both parallel and series MESFETs. Any use of Schottky diodes has been restricted to the level-shifting required by the circuit.

At this point, it is instructive to mention that Schottky diodes are well suited to directly accomplish the desired logic function. Some of the attractive features of the Schottky GaAs diodes: low capacitance, low series resistance, plus none of the problems associated with *pn* junction diodes. An additional advantage is realized in chip real estate in that Schottky diode can be made physically smaller than MESFETs. The disadvantage to SDFL lies in poor fanout which can be cured by the addition of a follow-on buffer circuit, but this brings the power consumption of the circuit up to that of BFL. Another disadvantage of SDFL is each gate may require individual crafting of the element sizes, which in turn may cascade into a whole series of requisite design changes. For an example of a DTL NOR gate, see Figure 3.5 on page 10.

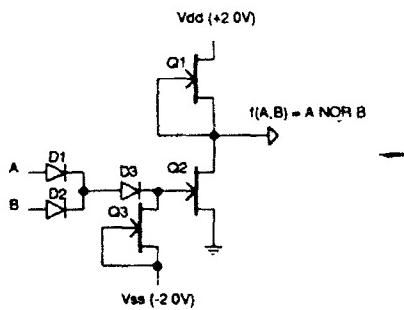


Figure 3.5 Gallium Arsenide DTL NOR gate [Ref. 1:p. 8]

The DTL NAND requires even more diodes and MESFETs than the DTL NOR. For an example of a DTL NAND gate, see Figure 3.6 on page 11.

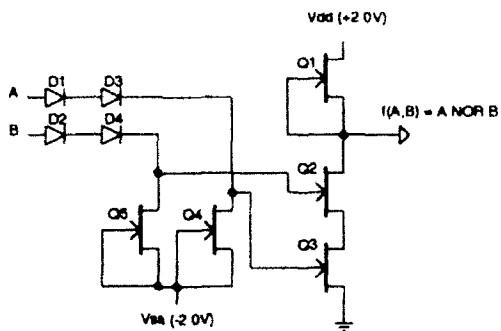


Figure 3.6 Gallium Arsenide DTL NAND gate [Ref. 1:p. 8]

B. GALLIUM ARSENIDE ENHANCEMENT-MODE LOGIC FAMILIES

Thus far, the discussion of GaAs logic families has been restricted to depletion-mode MESFETs. Enhancement-mode (normally off) GaAs MESFETs may also be used to implement logic functions and circuits. Because the e-mode MESFET may be turned off with a V_{GS} of 0 volts, now V_{DS} and V_{GS} are both positive, no level-shifting is required, and this allows the use (generally) of a single power supply, V_{DD} . Additionally, the saturation voltage V_{Dsat} of an e-mode MESFET is less than that of a d-mode MESFET and this allows for lower power supply voltages which yields chip real estate savings and lower power consumption. The smaller logic voltage swing, 0.0V to a maximum of 0.7V (limited by forward conduction), may provide very high switching speeds.

Among the disadvantages of e-mode MESFETs are, first, the aforementioned smaller logic voltage swing requires careful uniformity of threshold voltages which places additional constraints on the fabrication process. A second disadvantage of e-mode MESFETs is that they are not particularly suited to being used as active loads because the charging current diminishes as the voltage across the load capacitor increases. This requires the use of d-mode MESFETs for the active load current sources of e-mode logic circuits.

1. Direct-Coupled FET Logic (DCFL)

DCFL provides the simplest and most widely used GaAs e-mode logic circuits. See Figure 3.7 on page 12 for an example of a DCFL 2-input NOR gate. Note the similarity between the mixed GaAs e-mode / d-mode MESFETs used there and those of E/D NMOS circuits. The active load, current source pull-up is accomplished using the aforementioned d-mode MESFET (Q1).

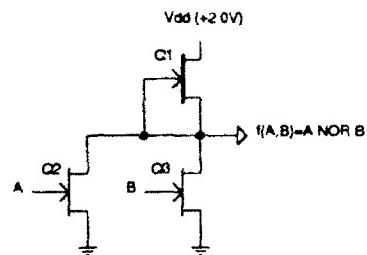


Figure 3.7 Gallium Arsenide DCFL NOR gate [Ref. 1:p. 10]

The DCFL NAND gate is very similar in structure to the NAND gates previously presented. The use of the active pull-up (Q1) precludes the previously used follow-on stages. See Figure 3.8 on page 12 for an example of DCFL NAND gate. It should be mentioned again that the use of so called "real" NAND gates is infrequent because of the series MESFETs, Q2 & Q3. These series MESFETs slow the operation of the circuit and therefore NAND gates constructed of NOR gates are almost exclusively used.

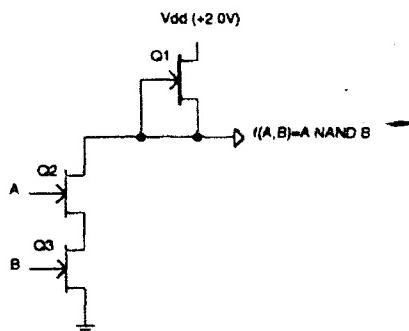


Figure 3.8 Gallium Arsenide DCFL NAND gate [Ref. 1:p. 10]

At this point it is illustrative to introduce the most basic logic gate, that of an inverter. See Figure 3.9 on page 13 for an example of a DCFL inverter logic gate. The symbol "/" preceding the "A" means "NOT A".

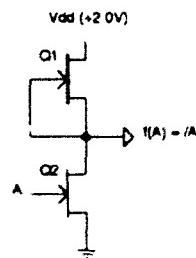


Figure 3.9 Gallium Arsenide DCFL INVERTER gate [Ref. 1:p. 11]

DCFL logic circuits offer fast switching speed but small noise margins (on the order of 200 millivolts, both high and low). These small noise margins require that the fabrication process pay particular attention to the material integrity and process parameters. Additionally, the fanout load for DCFL logic circuits is generally limited to two DCFL logic gates. The constraints placed on the logic designer by DCFL logic's low fanout and smaller noise margins lead to the incorporation of a buffer stage, this subfamily of DCFL is known as superbuffer FET logic. The topic GaAs DRAM integrated circuit chip was designed almost exclusively using DCFL and SBFL logic gates.

2. Superbuffer FET Logic (SBFL)

The peak load current - static current ratio of a DCFL inverter can be significantly improved through the addition of a quasi-complementary output driver (superbuffer). See Figure 3.10 on page 13 for the example schematic of a SBFL inverter.

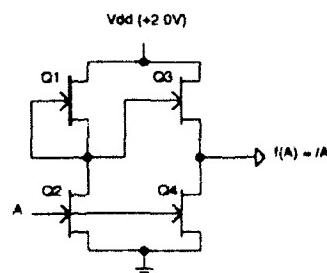


Figure 3.10 Gallium Arsenide SBFL INVERTER gate [Ref. 10:p. 215]

Note that the d-mode MESFET (Q1) acts again as an active load current source. Use of SBFL requires that the designer provide ample power bus width for the momentary voltage drop which occurs prior

to the HIGH to LOW transition. It is instructive to note that once the DCFL inverter, transistors Q_1 and Q_2 , passes its propagation delay, the load (connected between Q_3 and Q_4) will receive the full current capability of either Q_3 or Q_4 . The addition of the superbuffer solves, to some extent, the poor fanout and smaller noise margin shortcomings of DCFL but adds propagation delay and requires more chip real estate in exchange. It should be mentioned that the static power of the SBFL driver (Q_3 and Q_4) is equal to the static power of the DCFL inverter (Q_1 and Q_2). A further illustration of SBFL gates, a SBFL NOR gate, may be seen in Figure 3.11 on page 14.

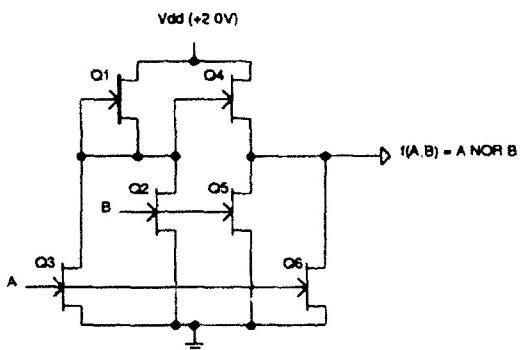


Figure 3.11 Gallium Arsenide SBFL NOR gate [Ref. 10:p. 215]

The extra chip real estate required and the increased power requirements of the superbuffer stage limit the use of the SBFL gates to those situations in which the fanout is unusually high and high speed is mandatory, such as clock drivers. This specific topic will be more thoroughly discussed in the succeeding chapters. One last note on SBFL, as noted on [Ref. 10:p. 216], a direct comparison between SBFL and DCFL ring oscillators yielded SBFL gate delays of 178 picoseconds and DCFL gates delays of 276 picoseconds.

3. Other GaAs E-mode Logic Families

Several other GaAs e-mode logic families exist: source-coupled FET logic (SCFL) which is very fast, E/D Buffered FET Logic (E/D BFL) which combines the best use of e-mode and d-mode GaAs MESFETs with BFL, pass transistor logic and complementary junction FET (JFET) logic. For a very thorough discussion of these additional GaAs e-mode logic families, the reader may peruse [Ref. 10:pp. 216-231].

The succeeding chapters will begin to discuss the actual logic elements used and the circuits which make up the GaAs DRAM.

IV. GALLIUM ARSENIDE DRAM LOW-LEVEL CIRCUITS

During the course of the design a multitude of different GaAs logic circuits were designed, tested and discarded for various reasons. Some of the reasons included poor noise margins and low fanout capabilities which did not become obvious until the target elements were placed into a larger circuit which then failed to function correctly. In addition, while no specific attempt was made at overall power consumption optimization, it was considered to be one of the factors while the design was in progress. The overriding factor that was used in judging the operation of the target GaAs logic element was a combination of speed and fanout. Early in the design cycle, little attention was paid to the mixing within a circuit of the various e-mode logic elements. After some time, it became obvious that DCFL will drive approximately two DCFL gates and perhaps as few as one SBFL gate, whereas SBFL could drive more than two DCFL gates, but usually at a slower speed. When germane, these issues will be mentioned in the discussion that follows.

A. GaAs DRAM DCFL Logic Circuits

The greatest majority of the GaAs DRAM circuits were designed using DCFL gates. This section will present the specific DCFL gates designed, tested, and used, presenting the schematic and logical equivalence for each. The following characteristics for each circuit will be demonstrated and presented: transient analysis under standard load, power consumption at nominal and high temperature, propagation delays and noise margins. These characteristics will be further summarized in TABLE 4.1 on page 158.

1. DCFL Inverter (DINV)

The basic and most widely used DCFL logic element was the inverter, hereafter called "DINV" for DCFL Inverter. As previously mentioned, true NAND gates were infrequently used, the more common ANDs, NANDs, and ORs were built using NORs with DINVs as per DeMorgan's theorems. See Figure 4.1 on page 16 for the DINV schematic and logical equivalence.

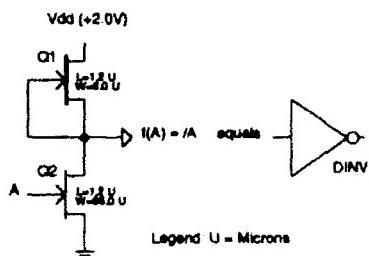


Figure 4.1 Schematic and Logical Equivalence for DINV

The following graph, Figure 4.2 on page 17, shows the output of the DINV for the input of a 50% duty cycle 4200 picosecond (ps) square wave with an input LOW (L) = 0.063V and HIGH (H) = 0.63V. The DINV was tested with two DINVs connected in parallel to the output as a standard DCFL load. Notice how the LOW to HIGH transition is somewhat slower than the HIGH to LOW transition. This is caused by the use of the active load pull-up Q1 (see Figure 4.1 on page 16). The pull-up transistor never turns completely off and this causes the delay in the LOW to HIGH transition. Similar LOW to HIGH transition characteristics are displayed by E/D NMOS logic circuits. The lower graph of Figure 4.2 on page 17 indicates the power dissipation of DINV operating at a temperature of 25.0C under a standard load of two DCFL Inverters (DINVs). See "Listing File for DINV Transient Analysis at 25.0C" of Appendix A on page 259.

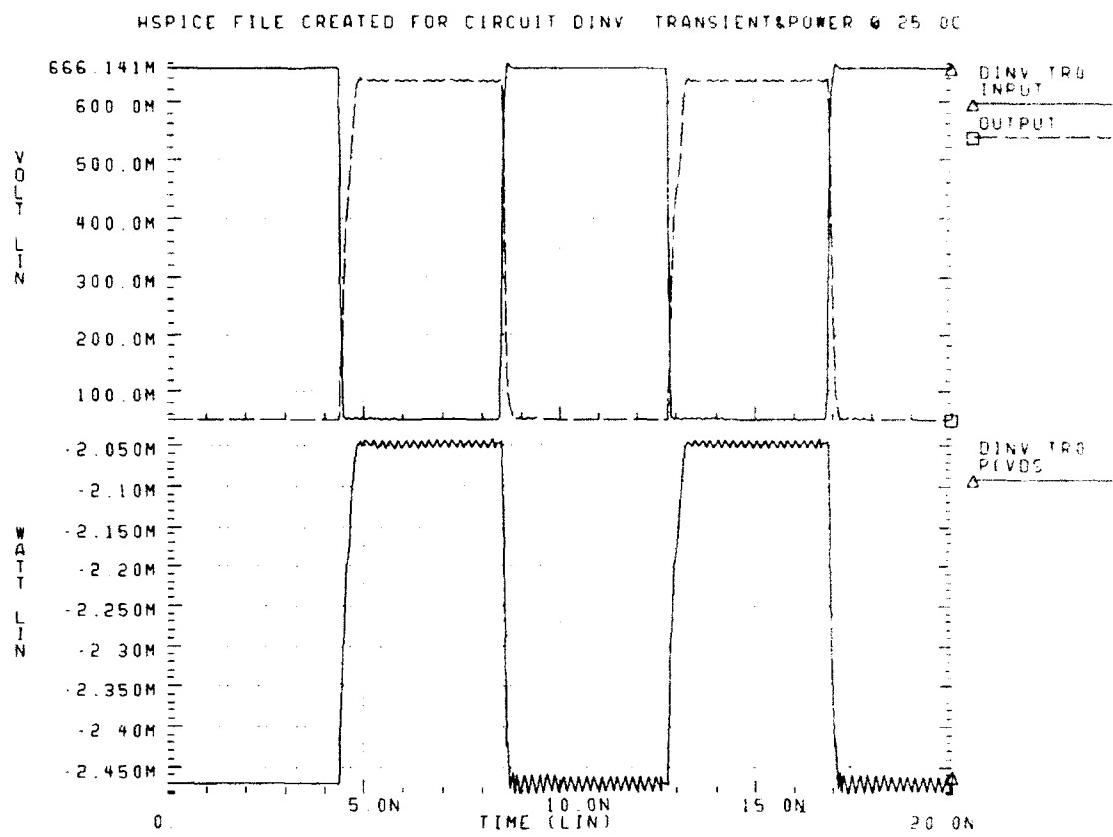


Figure 4.2 DINV HSPICE Transient Analysis and Power Dissipation at 25.0C

Temperature affects both the transient analysis and the DC transfer curve characteristics (from which the noise margins are calculated) for GaAs circuits. Whereas Figure 4.2 on page 17 (lower graph) shows the transient analysis of the DINV at room temperature (25.0C), Figure 4.3 on page 18 indicates the increased power consumption and slightly slower speed of the same circuit operating at 85.0C.

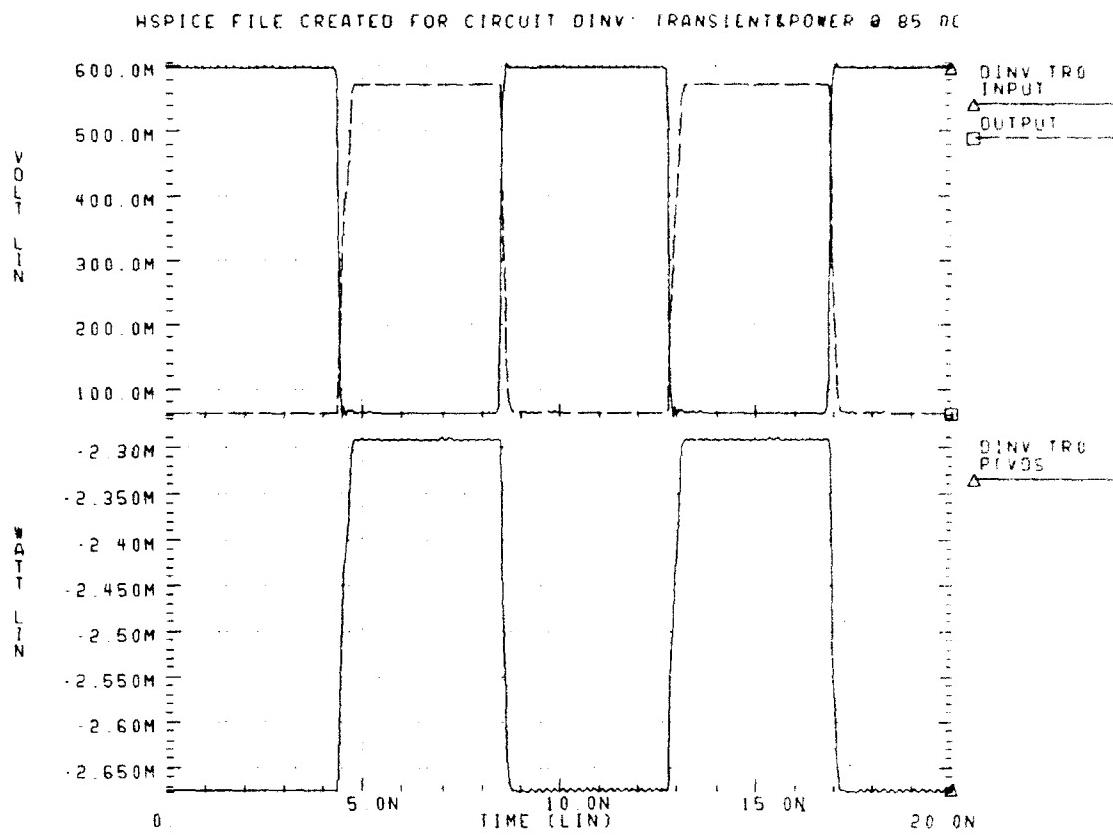


Figure 4.3 DINV HSPICE Transient Analysis and Power Dissipation at 85.0C

The noise margin calculations are calculated from the DC transfer curve for a DINV logic gate operating at 25.0C. See Figure 4.4 on page 19 for this graph. The noise margin calculation procedures are presented in this figure as used. This is the only example offered of noise margin calculation procedures though the noise margins for all the logic gates have been calculated and will be summarized in TABLE 4.1 on page 158. Reviewing Figure 4.4 on page 19, it is obvious that the noise margins are not as well balanced (NM_L versus NM_H) as may be desired. The cause of this shift of balance between NM_L and NM_H is the ratio of the physical size of the DINV pull-up MESFET relative to the size of the DINV pull-down MESFET. (See the DINV MESFET sizes in Figure 4.1 on page 16). One of the GaAs logic circuit design rules is maintenance of a sixteen-to-one of pull-down to pull-up size ratio. This rule allows for some variance as the DINV was designed with a 1-to-1 ratio on the "front end" and a sixteen-to-1 ratio on the "back end". Not splitting the Gallium Arsenide MESFET gate length versus gate width ratio into the idealized 2-to-1 for gate length and 8-to-1 for gate width is the cause of these skewed noise margins.

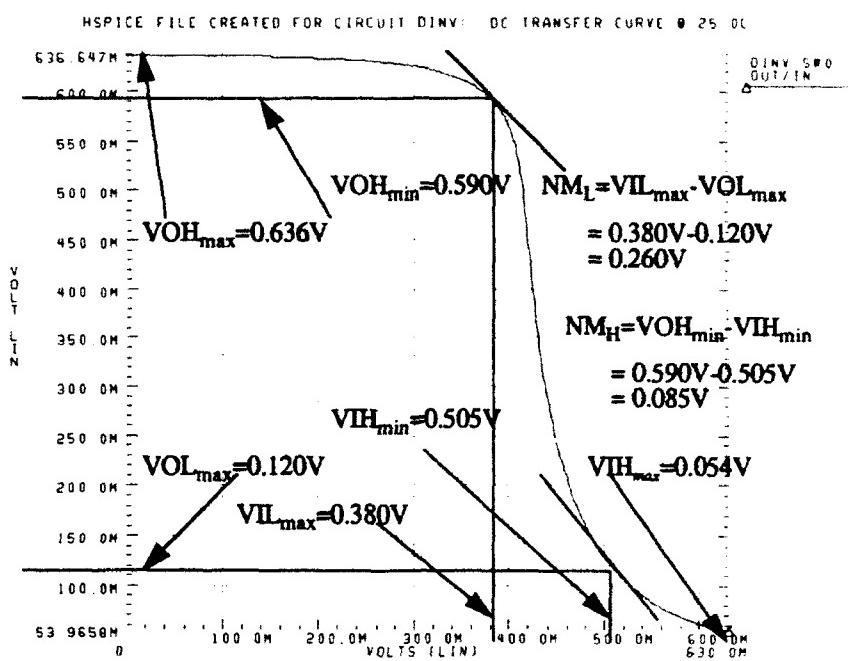


Figure 4.4 DINV DC Transfer Curve at 25.0C

The operating temperature of the circuit affects the noise margins as well as power dissipation and transient operating characteristics, see Figure 4.5 on page 20 for the DC transfer curve for a DINV logic gate operating at 85.0C. One can see that the relative position of the DC transfer curve has shifted somewhat, though the noise margins were not improved significantly. See TABLE 4.1 on page 158 for the specific noise margins for each logic gate.

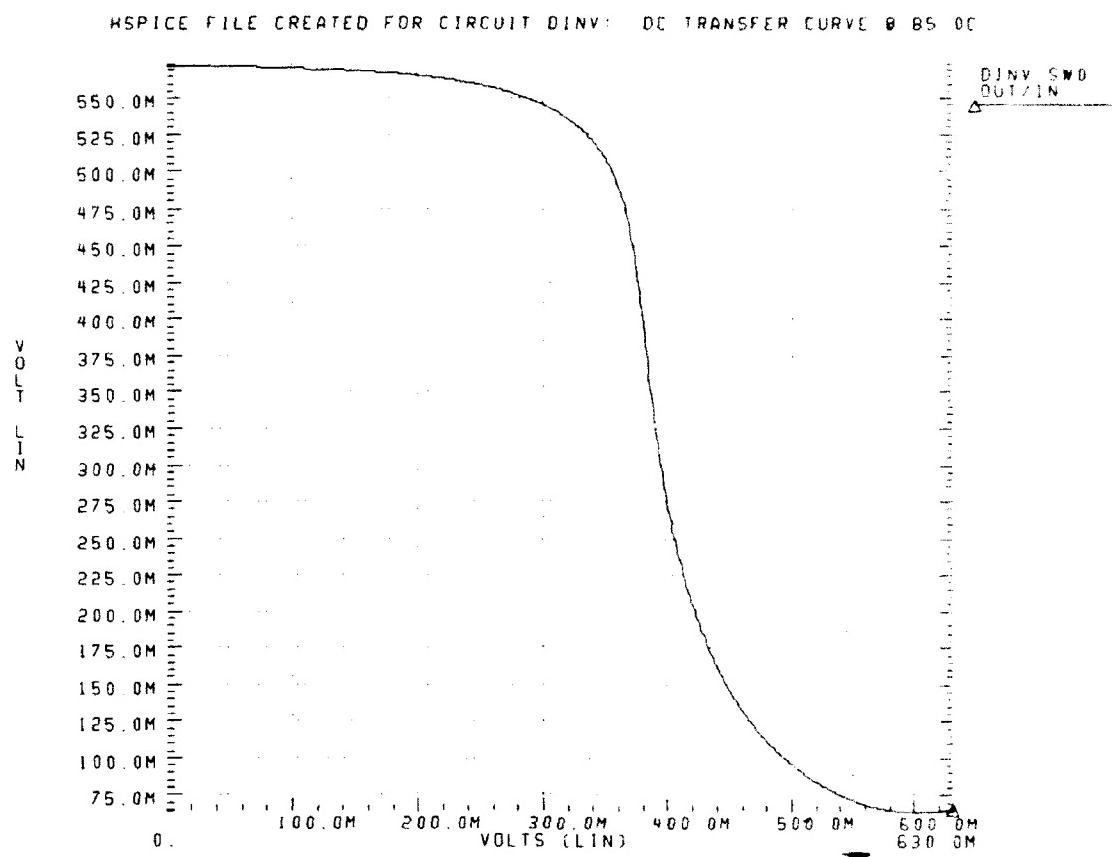


Figure 4.5 DINV DC Transfer Curve at 85.0C

2. DCFL 2-Input NOR (D2NOR)

The following graphs represent the operating characteristics of the D2NOR. The D2NOR schematic and logical representation are shown in Figure 4.6 on page 21. Figure 4.7 on page 21 indicates the transient analysis and power dissipation of the D2NOR logic gate at an operating temperature of 25.0C. The transient voltage spike shown in the output of Figure 4.7 (upper graph) (occurring at approximately 8.0 nanoseconds) is a result of non-overlapping input signals. That is to say, the first input signal goes LOW before the second input signal goes HIGH, consequently, the output begins to change from LOW to HIGH.

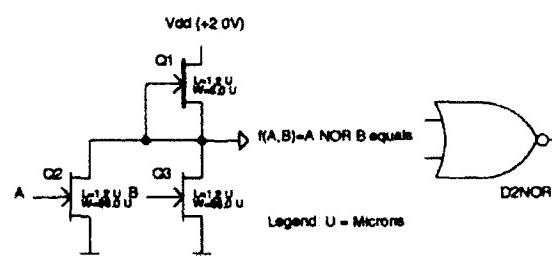


Figure 4.6 D2NOR Schematic and Logical Equivalence

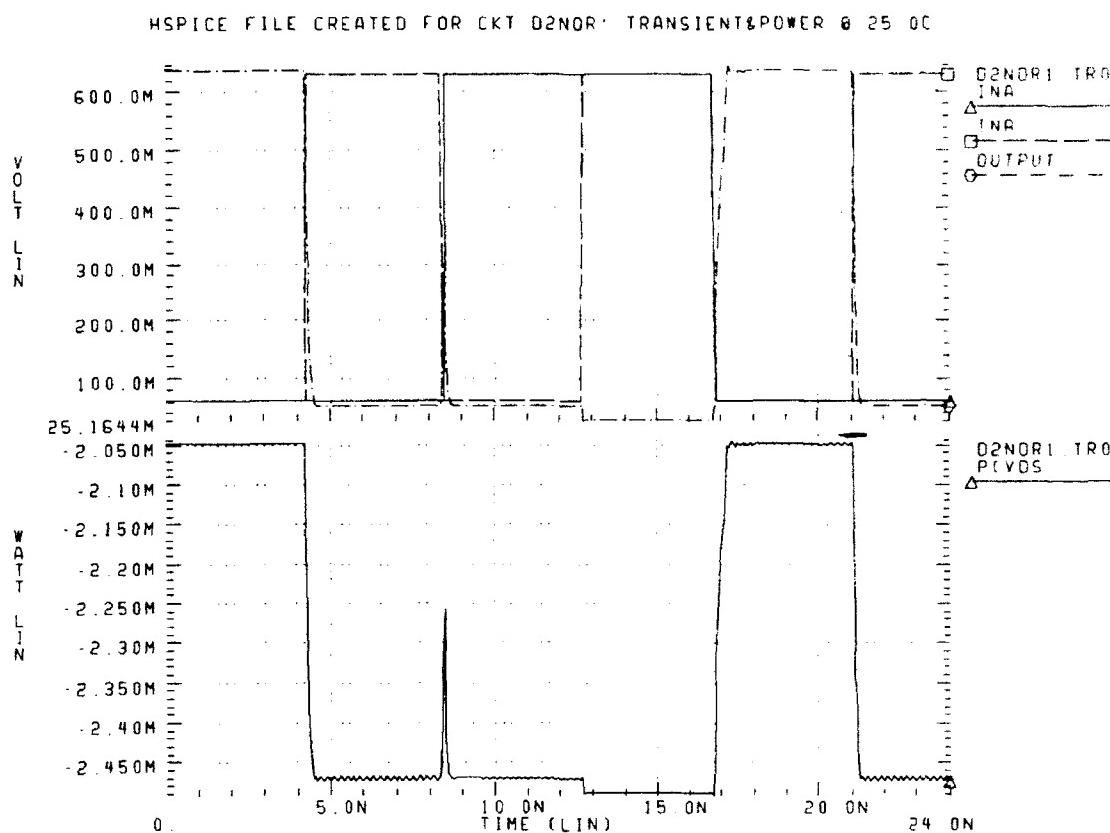


Figure 4.7 D2NOR HSPICE Transient Analysis and Power Dissipation at 25.0C.

Transient analysis and power dissipation for the D2NOR logic gate operating at 85.0C is displayed in Figure 4.8 on page 22. Notice the increased power dissipation caused by the higher operating temperature.

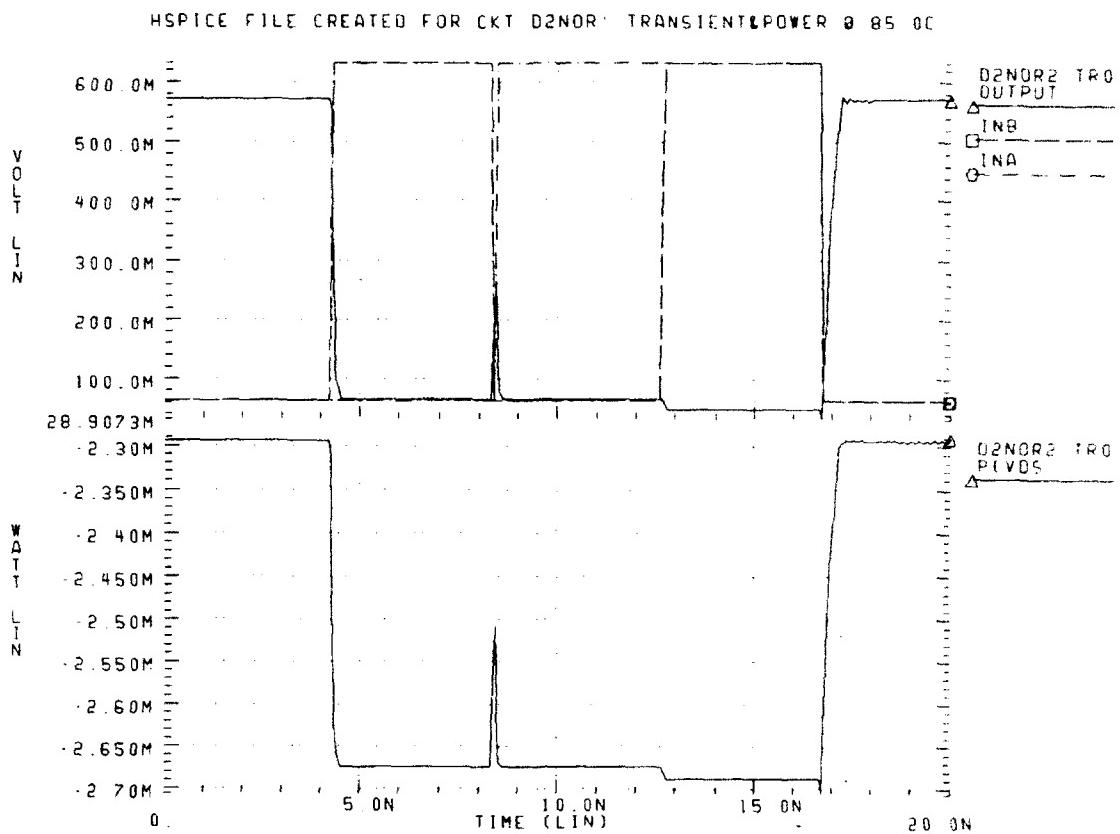


Figure 4.8 D2NOR HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the D2NOR logic gate operating at a temperature of 25.0C is shown in Figure 4.9 on page 23. Notice that in Figure 4.9, the DC transfer curve is again “skewed” or shifted. The same conscious design decision is again the culprit. See the previous discussion on skewed noise margins.

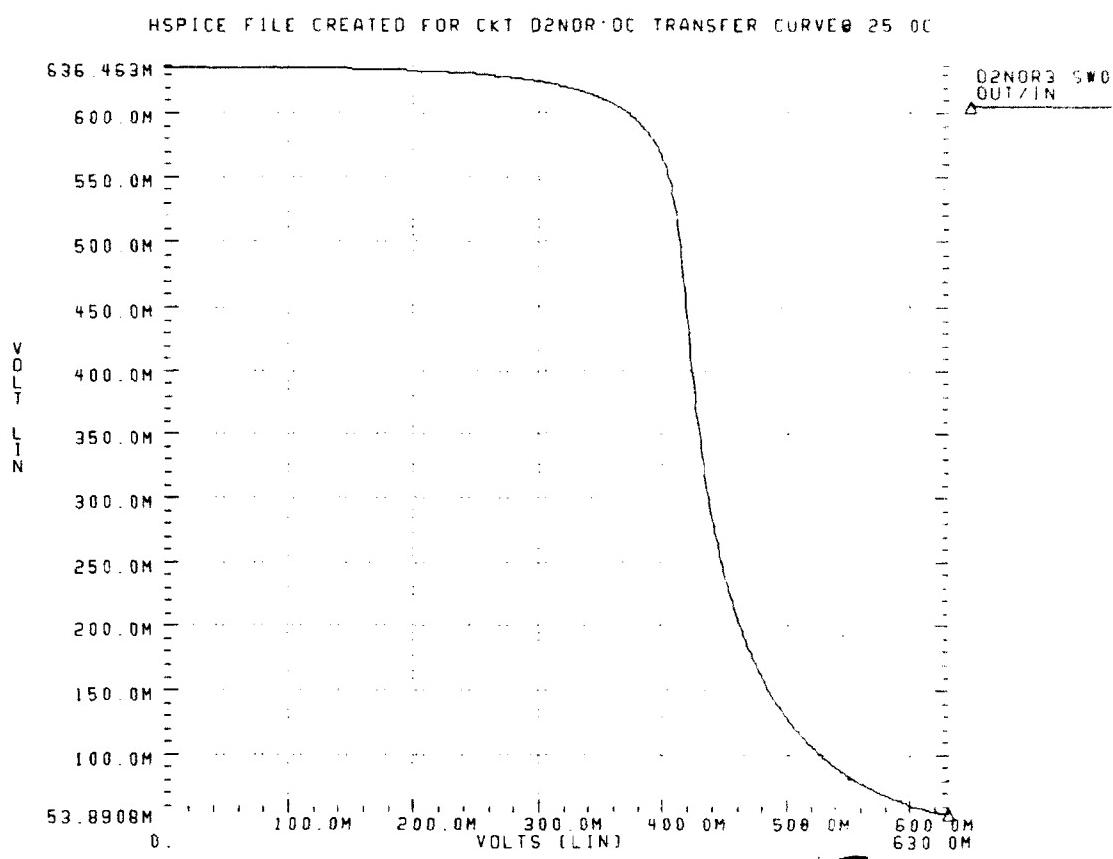


Figure 4.9 D2NOR DC Transfer Curve at 25.0C

The DC transfer characteristic of the D2NOR logic gate operating at a temperature of 85.0C is shown in Figure 4.10 on page 24.

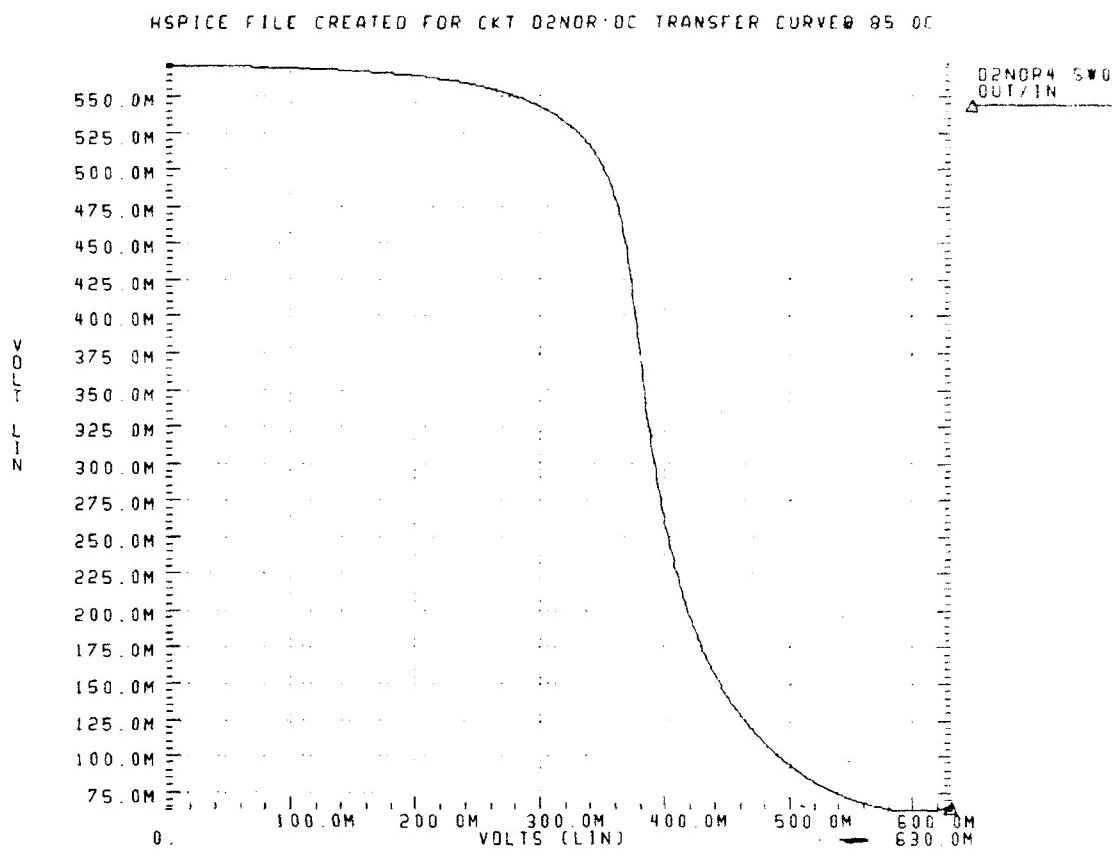


Figure 4.10 D2NOR DC Transfer Curve at 85.0C

3. DCFL 3-input NOR (D3NOR)

The following graphs represent the operating characteristics of the D3NOR. As previously mentioned, most GaAs DRAM logic gates were constructed of NORs, specifically DCFL NOR gates. The D3NOR schematic and logical representation are shown in Figure 4.11 on page 25. Notice again the sizing of the MESFETs and its associated effect on transient operation and noise margins.

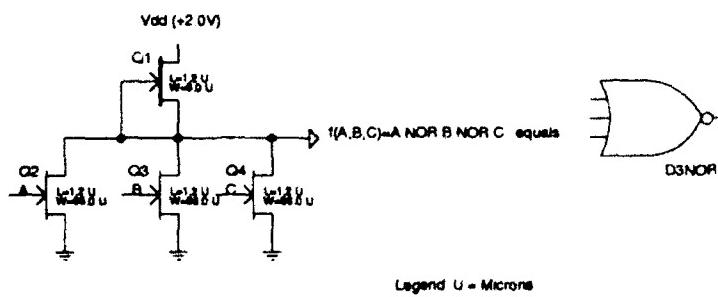


Figure 4.11 D3NOR Schematic and Logical Equivalence

Figure 4.12 on page 26 represents the transient analysis and power dissipation of the D3NOR logic gate at an operating temperature of 25.0C. The transient voltage spikes shown in the output of Figure 4.12 (upper graph) (occurring at approximately 9 nanoseconds and 17 nanoseconds) result from non-overlapping input signals as previously mentioned. It is interesting to note that the majority of the power dissipation occurs when the output is HIGH.

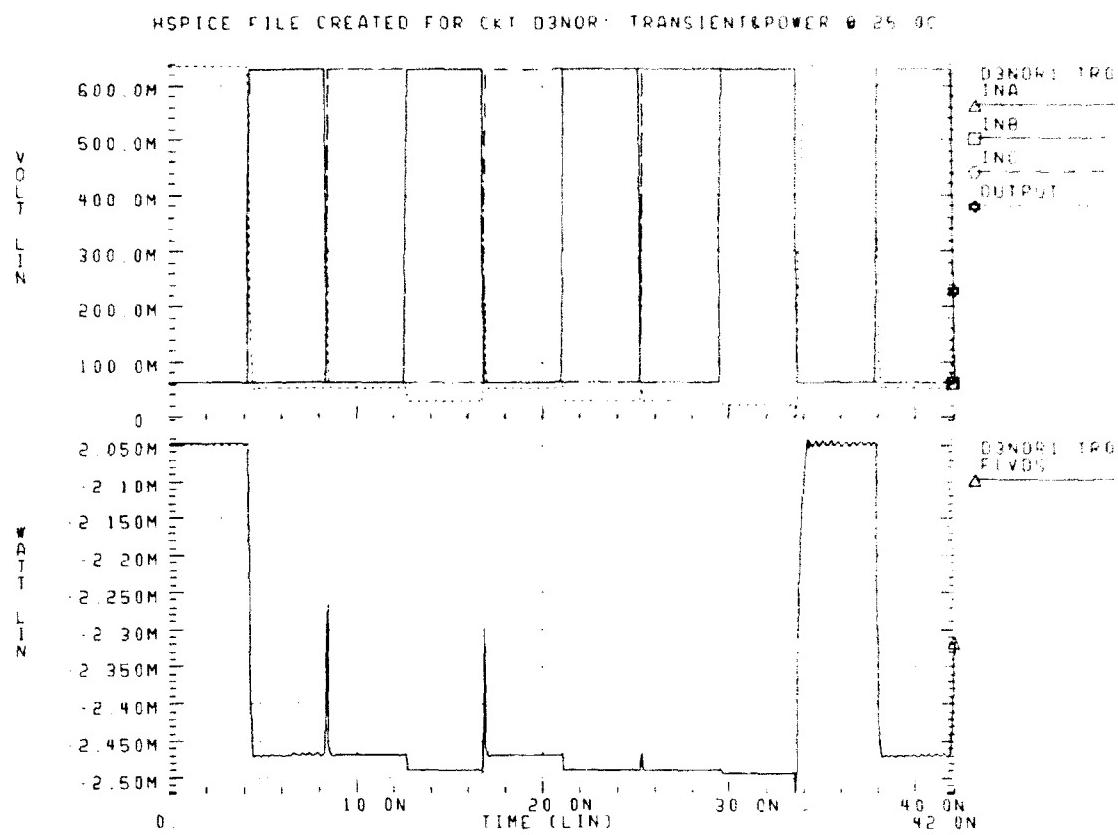


Figure 4.12 D3NOR HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the D3NOR operating at a temperature of 85.0C is shown in Figure 4.13 on page 27.

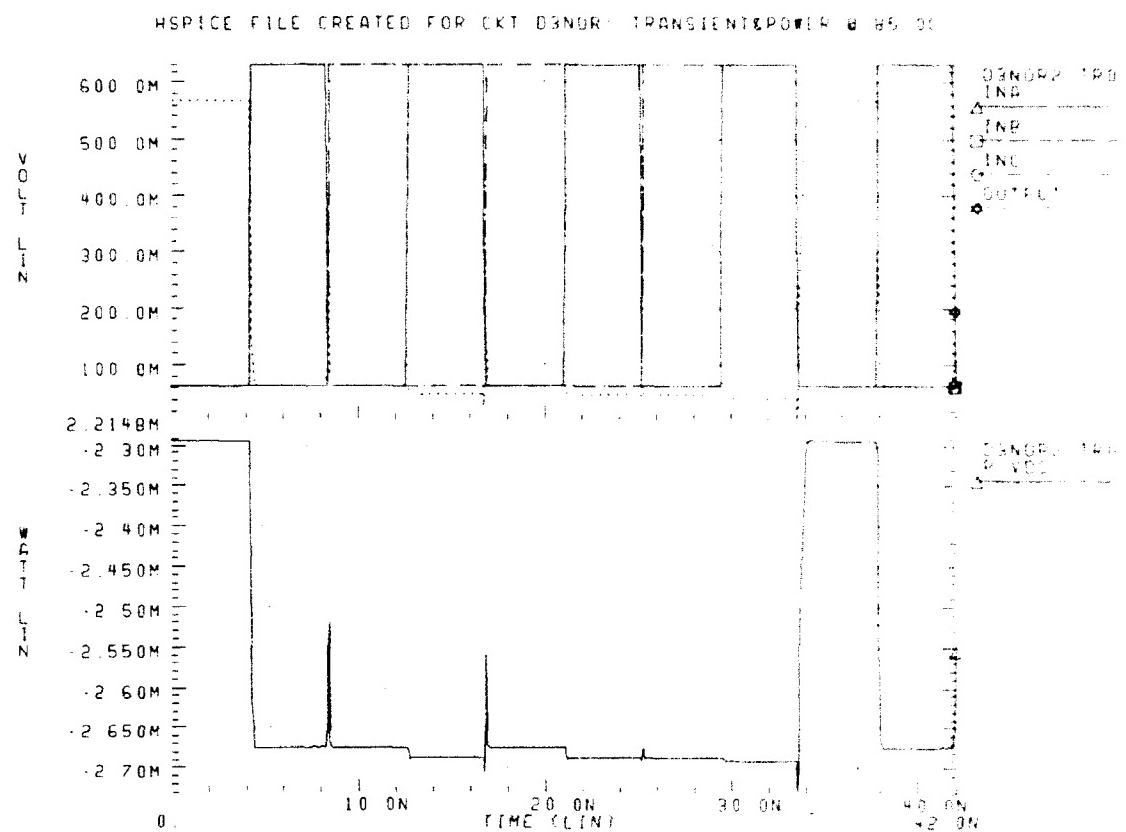


Figure 4.13 D3NOR HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the D3NOR logic gate operating at a temperature of 25.0C is shown in Figure 4.14 on page 28.

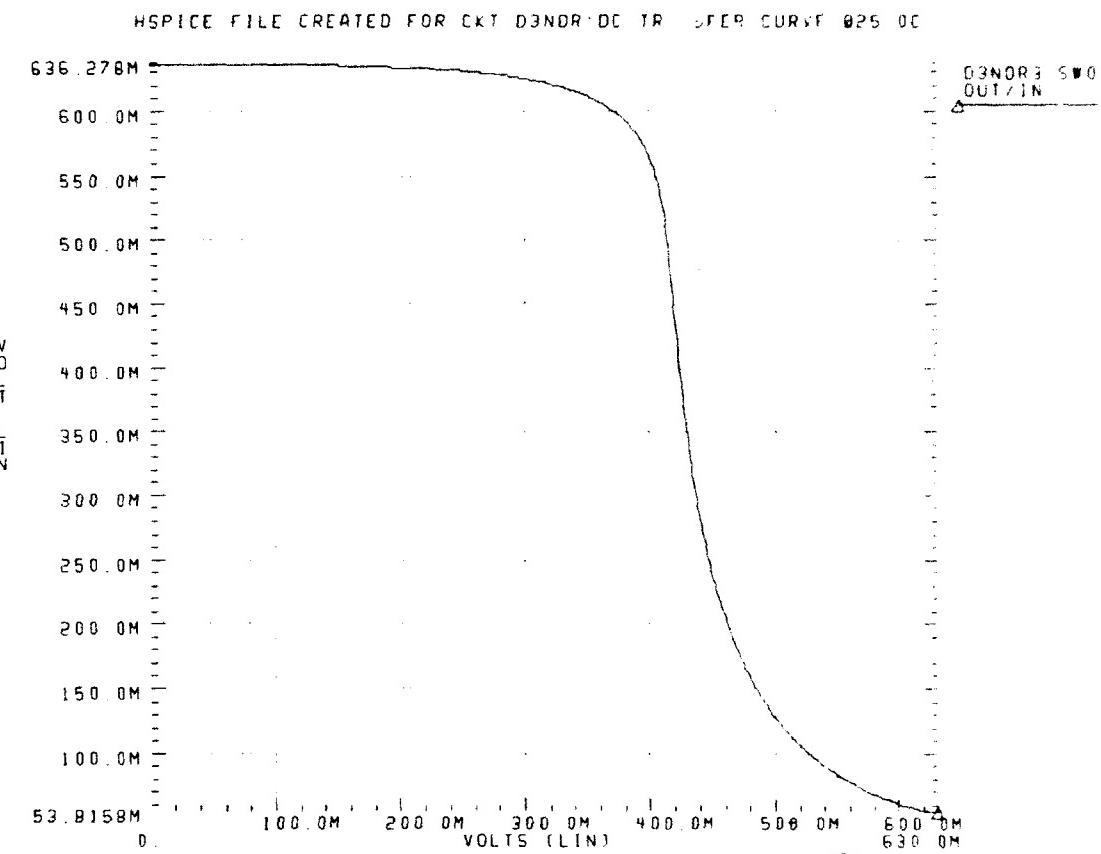


Figure 4.14 D3NOR DC Transfer Curve at 25.0C

The DC transfer characteristic of the D3NOR logic gate operating at a temperature of 85.0C is shown in Figure 4.15 on page 29.

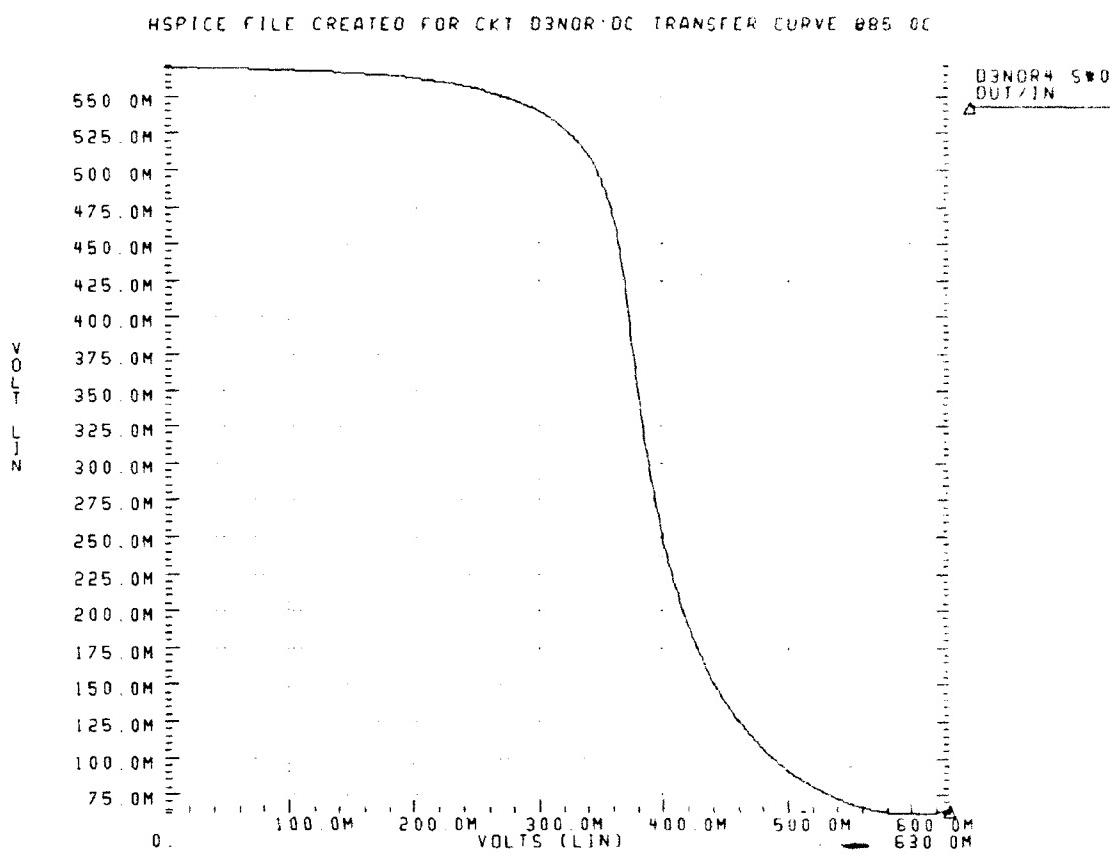


Figure 4.15 D3NOR DC Transfer Curve at 85.0C

4. DCFL 4-Input NOR Gate (D4NOR)

The following graphs represent the operating characteristics of the D4NOR. As previously mentioned, most GaAs DRAM logic gates were constructed of NOR's, specifically DCFL NOR gates. The D4NOR schematic and logical representation are shown in Figure 4.16 on page 30. Notice again the sizing of the MESFETs and its associated effect on transient operation and noise margins.

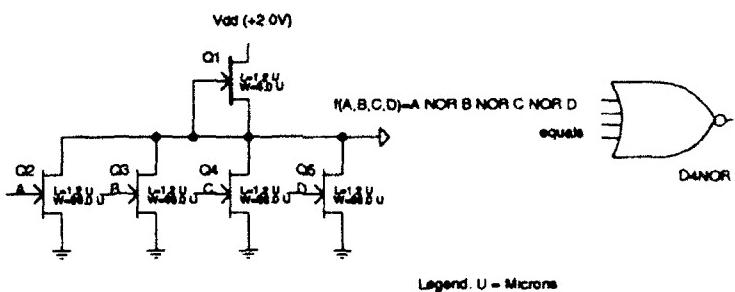


Figure 4.16 D4NOR Schematic and Logical Equivalence

The transient analysis and power dissipation of the D4NOR logic gate operating at a temperature of 25.0C is shown in Figure 4.17 on page 30. See "Listing File for D4NOR Transient Analysis @ 25.0C" of Appendix A on page 262.

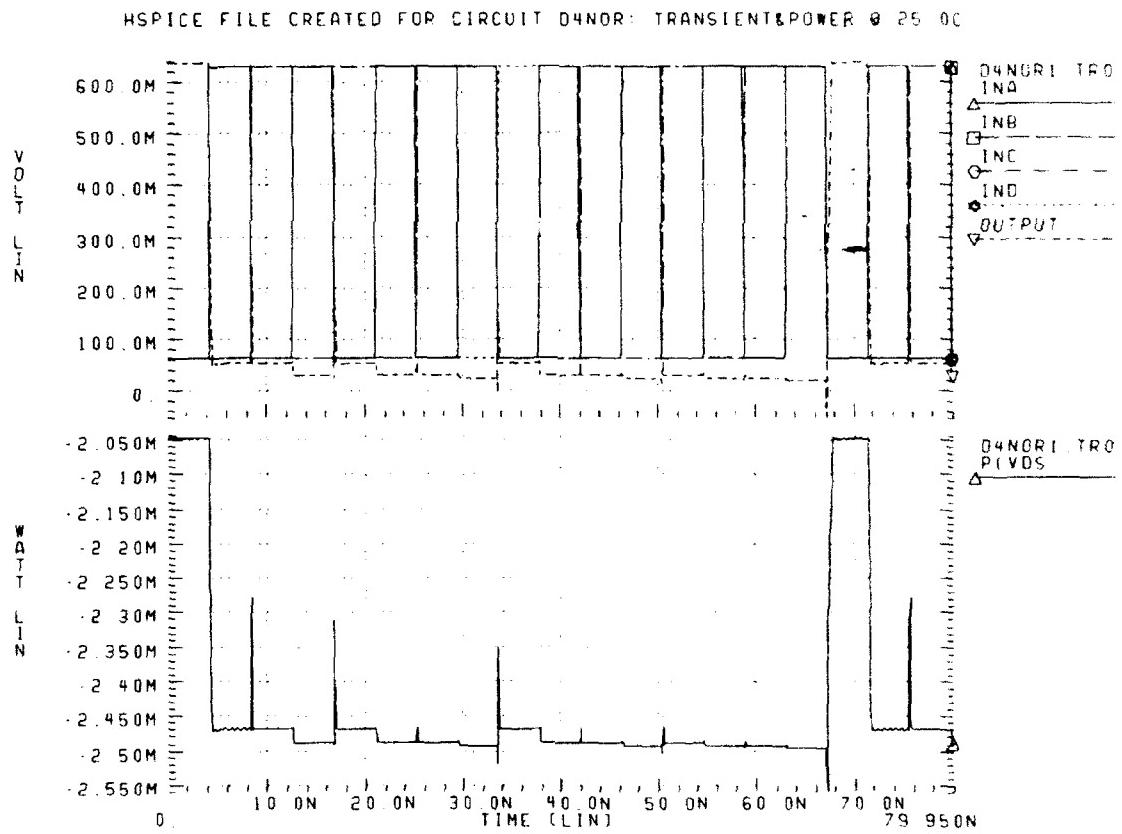


Figure 4.17 D4NOR HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the D4NOR operating at a temperature of 85.0C is shown in Figure 4.18 on page 31.

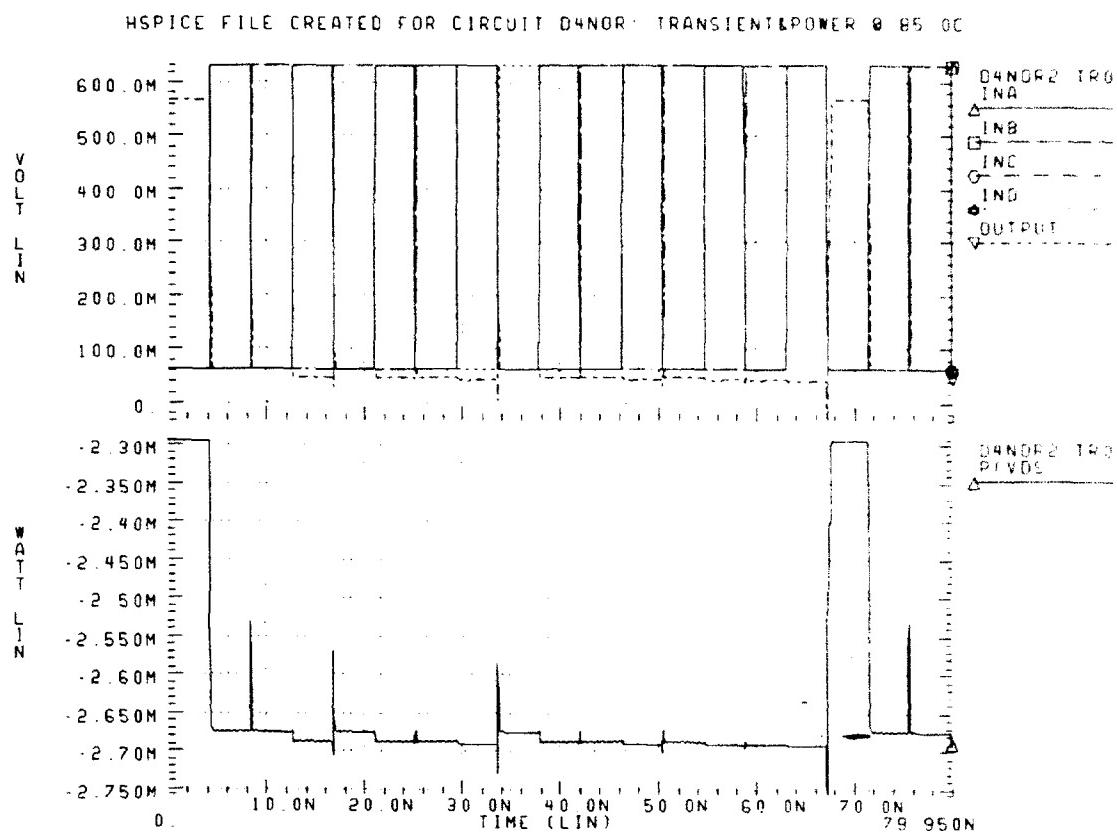


Figure 4.18 D4NOR HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the D4NOR logic gate operating at a temperature of 25.0C is shown in Figure 4.19 on page 32.

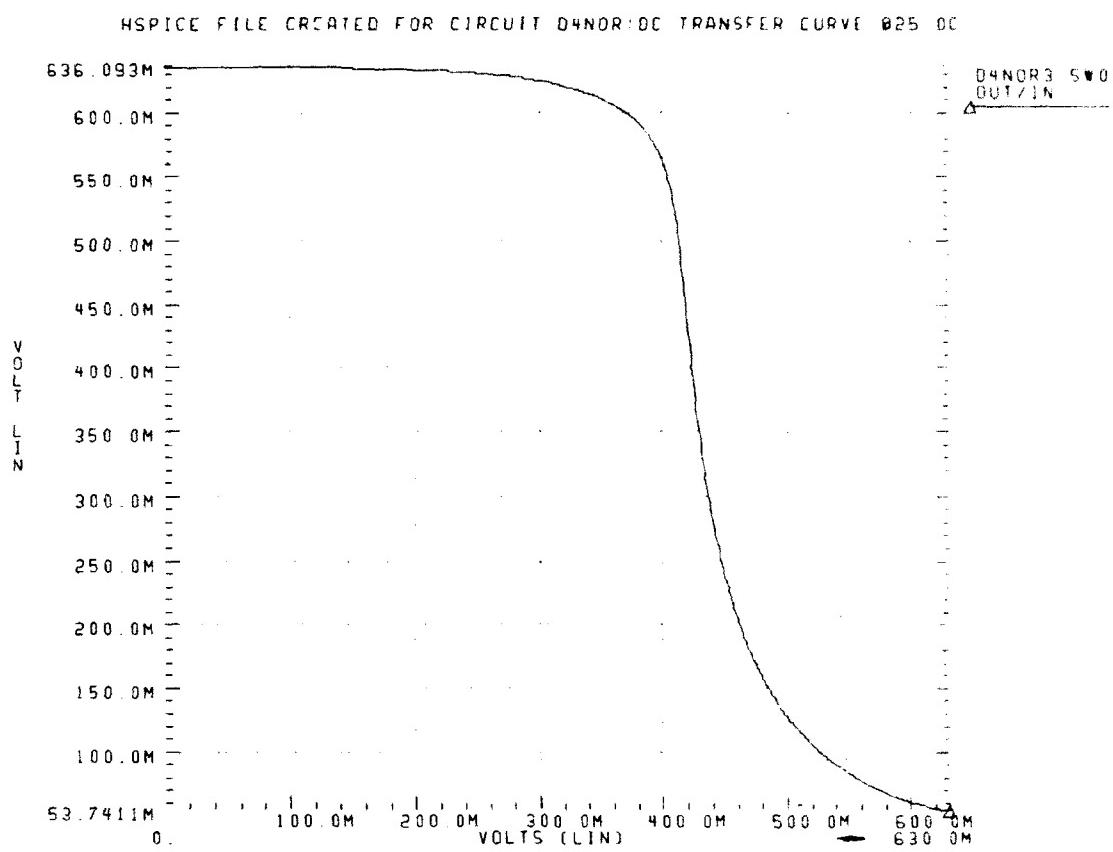


Figure 4.19 D4NOR DC Transfer Curve at 25.0C

The DC transfer characteristic of the D4NOR logic gate operating at a temperature of 85.0C is shown in Figure 4.20 on page 33.

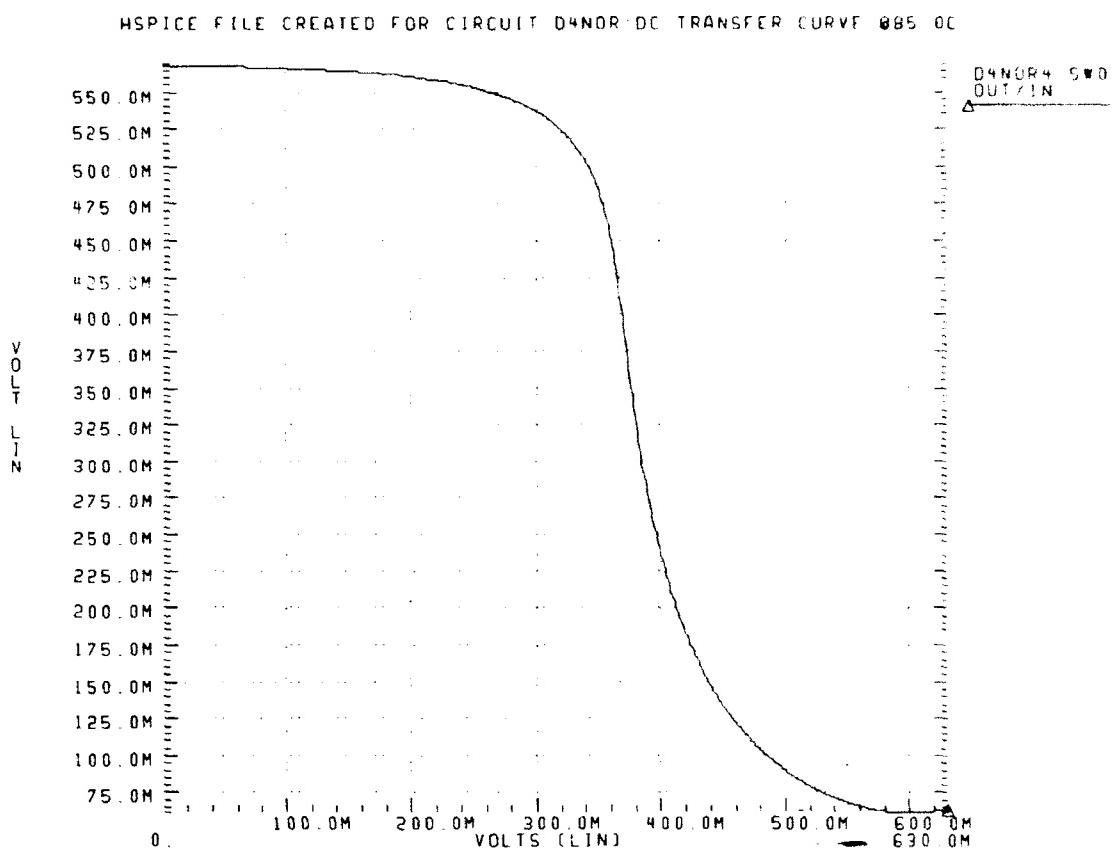


Figure 4.20 D4NOR DC Transfer Curve at 85.0C

5. DCFL 2-input True NAND Gate (D2NAND)

As previously mentioned, the largest majority of the DCFL GaAs DRAM logic gates are constructed from DCFL NOR gates. This gate, D2NAND, is an exception. It was necessary to use a true NAND gate in two fundamental circuits of the GaAs DRAM. These circuits are DLATCH and SDLATCH. The true NAND gate is very fast but as shown by its physical size in Figure 4.21 on page 34, it occupies considerable chip real estate. Figure 4.21 on page 34 presents the D2NAND schematic and logical equivalence.

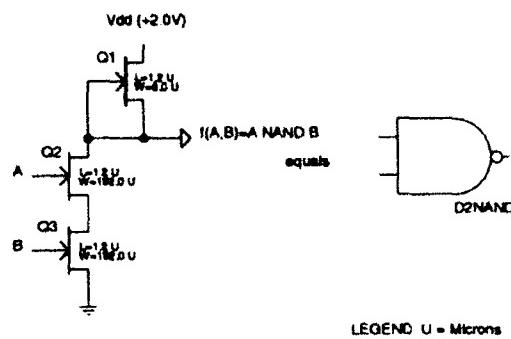


Figure 4.21 D2NAND Schematic and Logical Equivalence

The transient analysis and power dissipation of the D2NAND operating at a temperature of 25.0C is shown in Figure 4.22 on page 34.

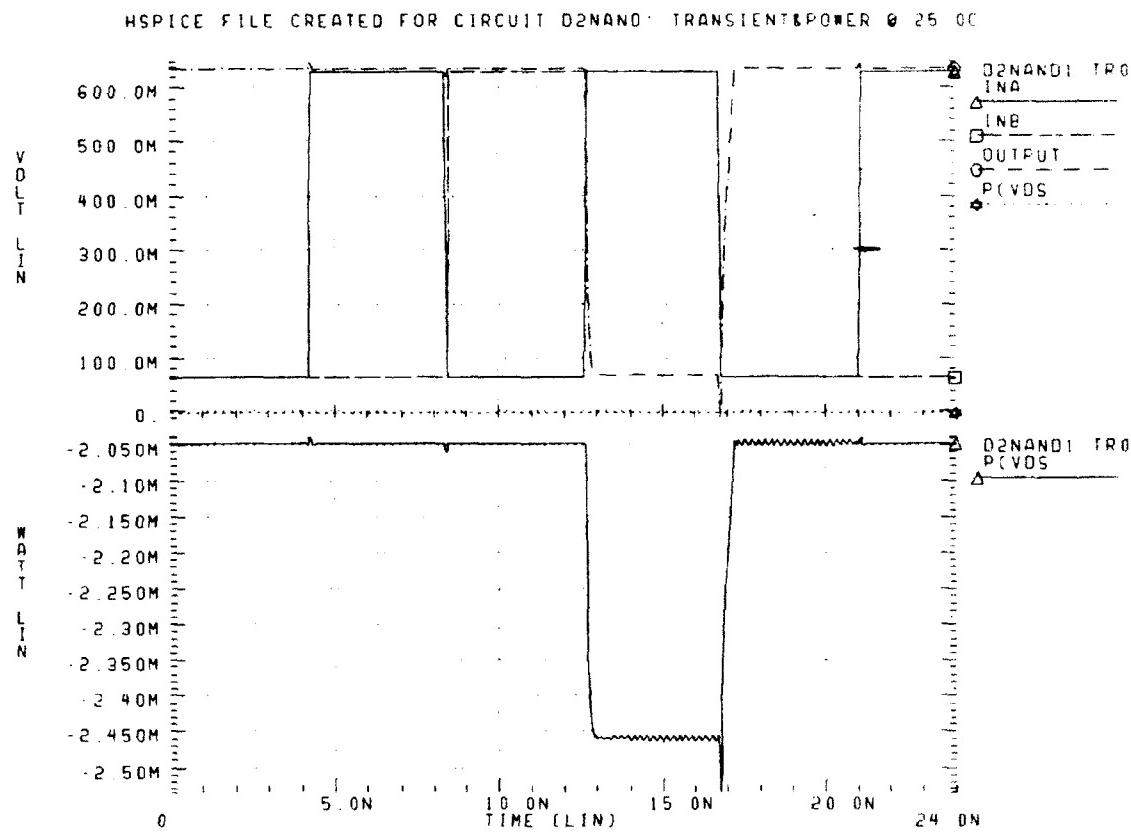


Figure 4.22 D2NAND HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the D2NAND operating at a temperature of 85.0C is shown in Figure 4.23 on page 35.

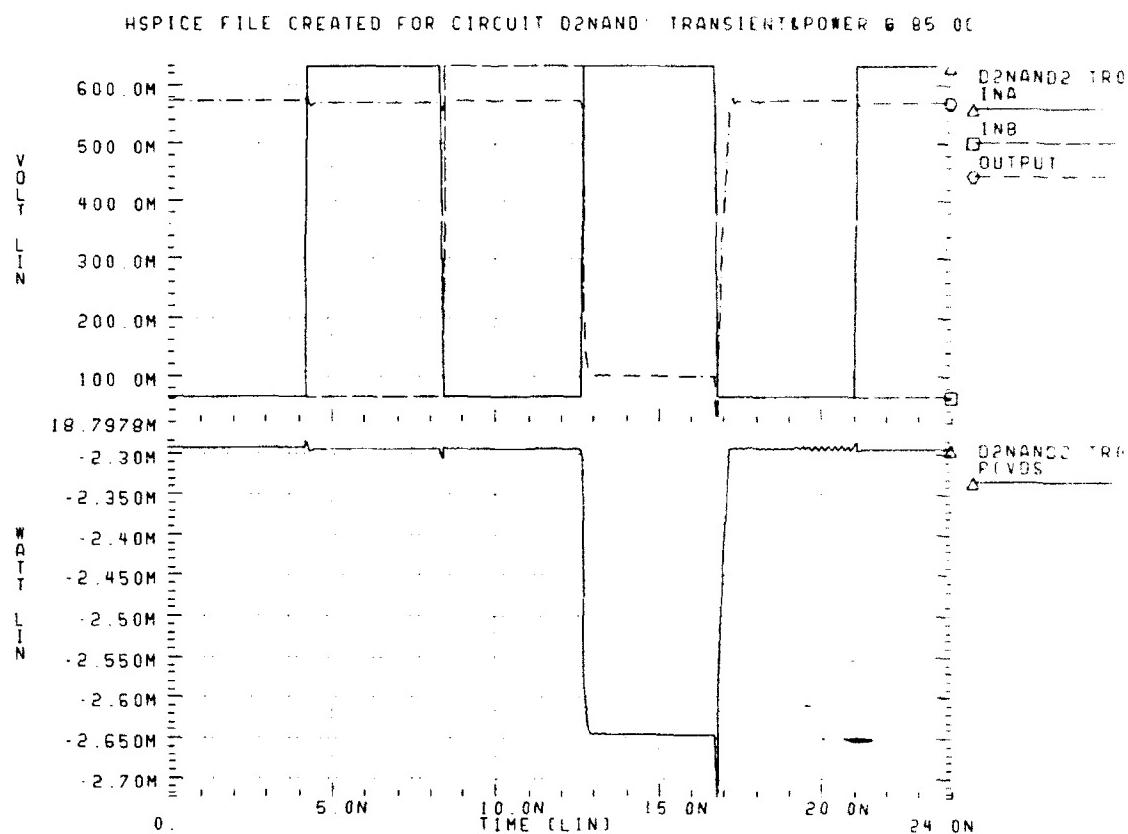


Figure 4.23 D2NAND HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the D2NAND logic gate operating at a temperature of 25.0C is shown in Figure 4.24 on page 36.

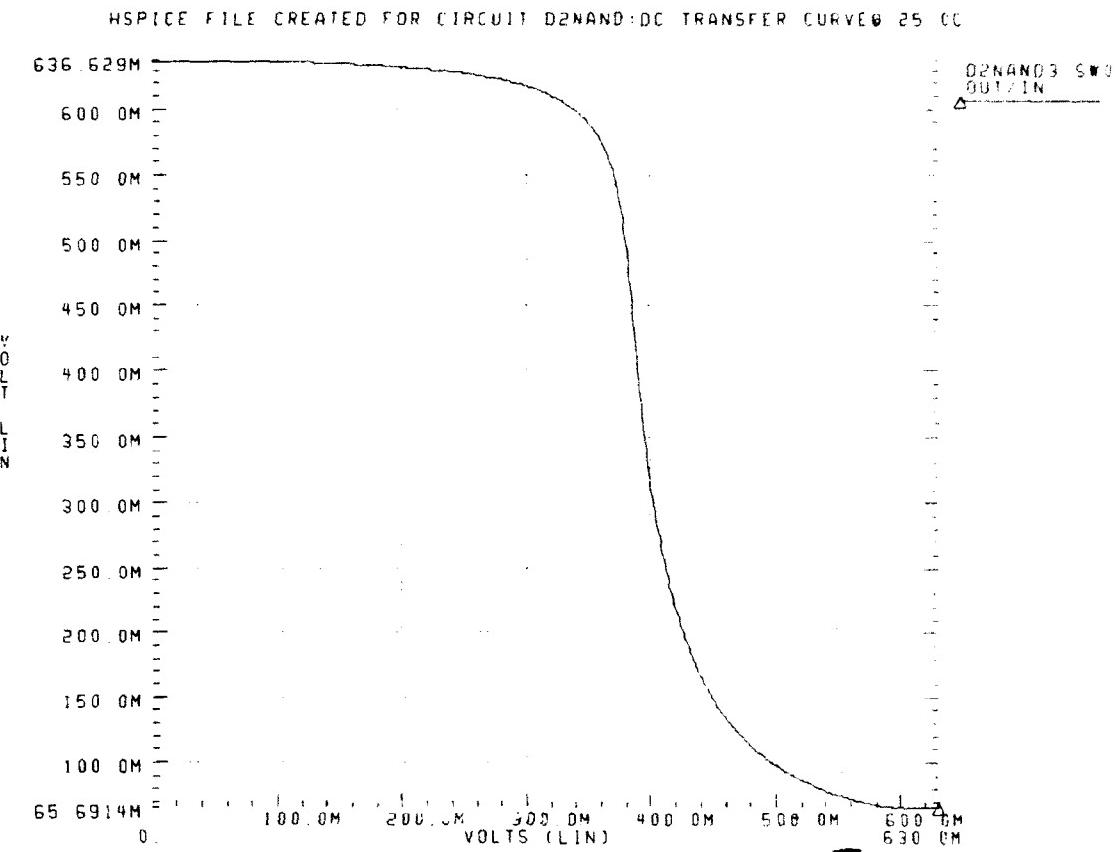


Figure 4.24 D2NAND DC Transfer Curve at 25.0C

The DC transfer characteristic of the D2NAND logic gate operating at a temperature of 85.0C is shown in Figure 4.25 on page 37.

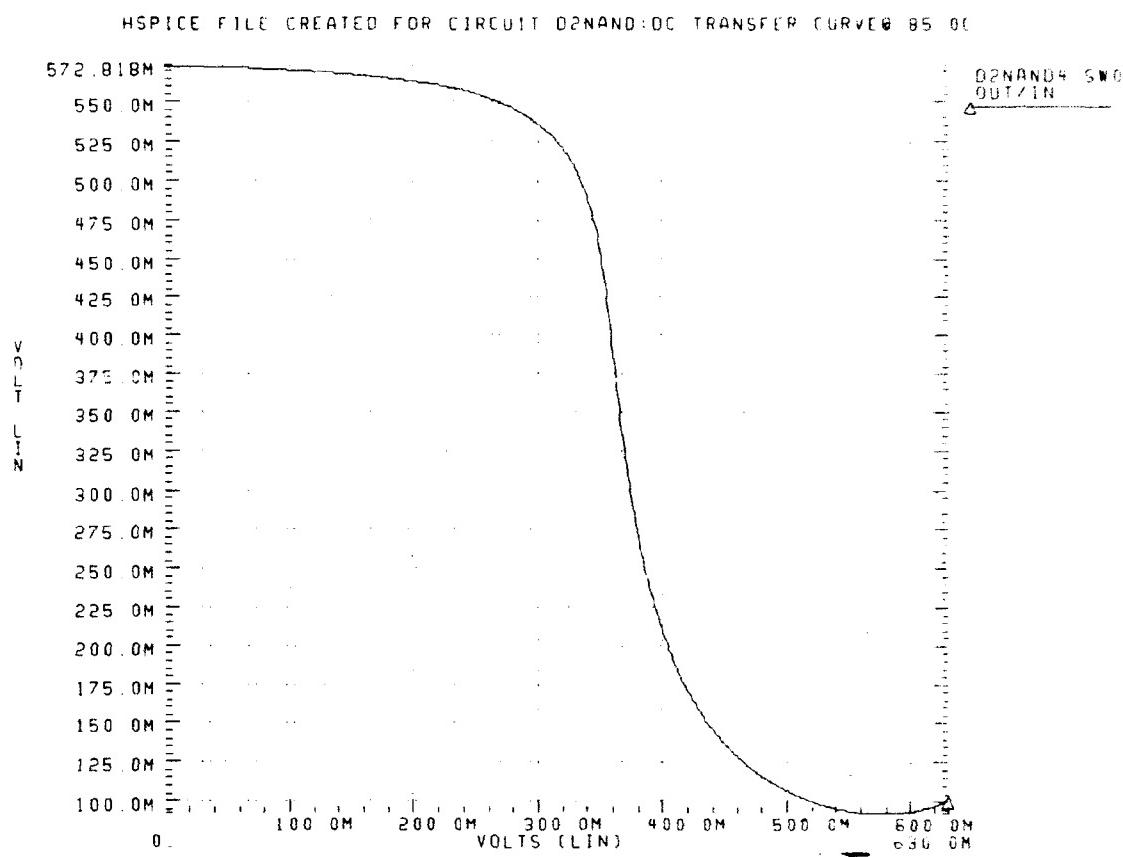


Figure 4.25 D2NAND DC Transfer Curve at 85.0C

6. DCFL 2-input NAND Gate (DD2NAND)

A DD2NAND logic gate is constructed using the DeMorgan equivalent of a D2NOR with two DINVs on its inputs and one DINV on its output. The end result is a DCFL 2-input NAND gate. Figure 4.26 on page 37 presents the DD2NAND schematic and logical equivalence.

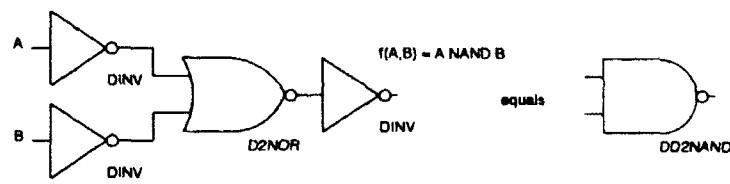


Figure 4.26 DD2NAND Schematic and Logical Equivalence

The transient analysis and power dissipation of the DD2NAND operating at a temperature of 25.0C is shown in Figure 4.27 on page 38.

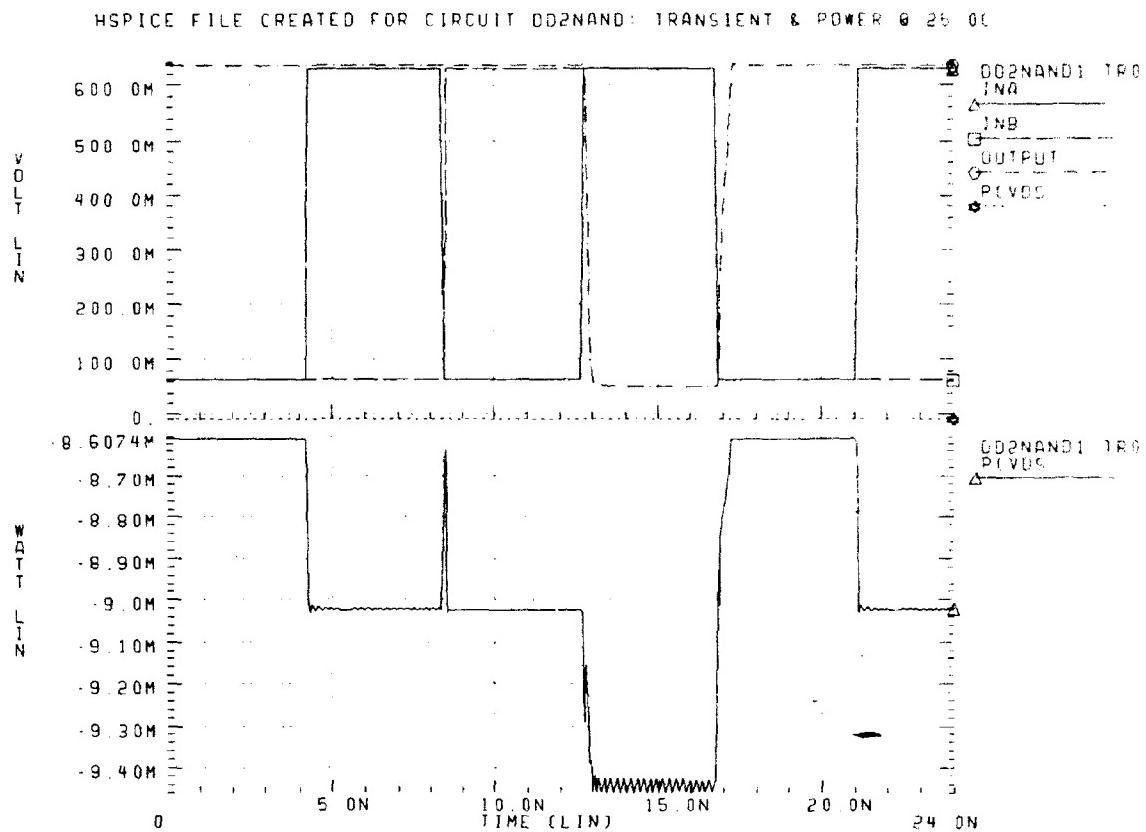


Figure 4.27 DD2NAND HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the DD2NAND operating at a temperature of 85.0C is shown in Figure 4.28 on page 39.

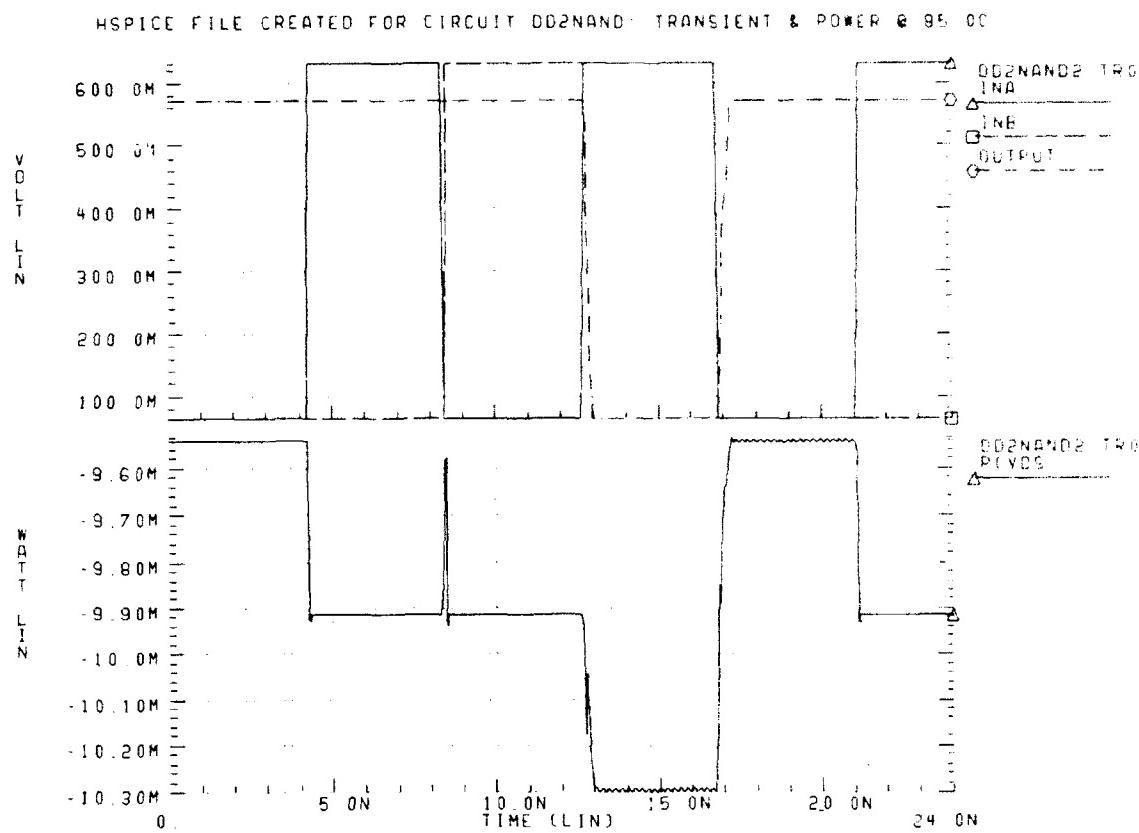


Figure 4.28 DD2NAND HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the DD2NAND logic gate operating at a temperature of 25.0C is shown in Figure 4.29 on page 40.

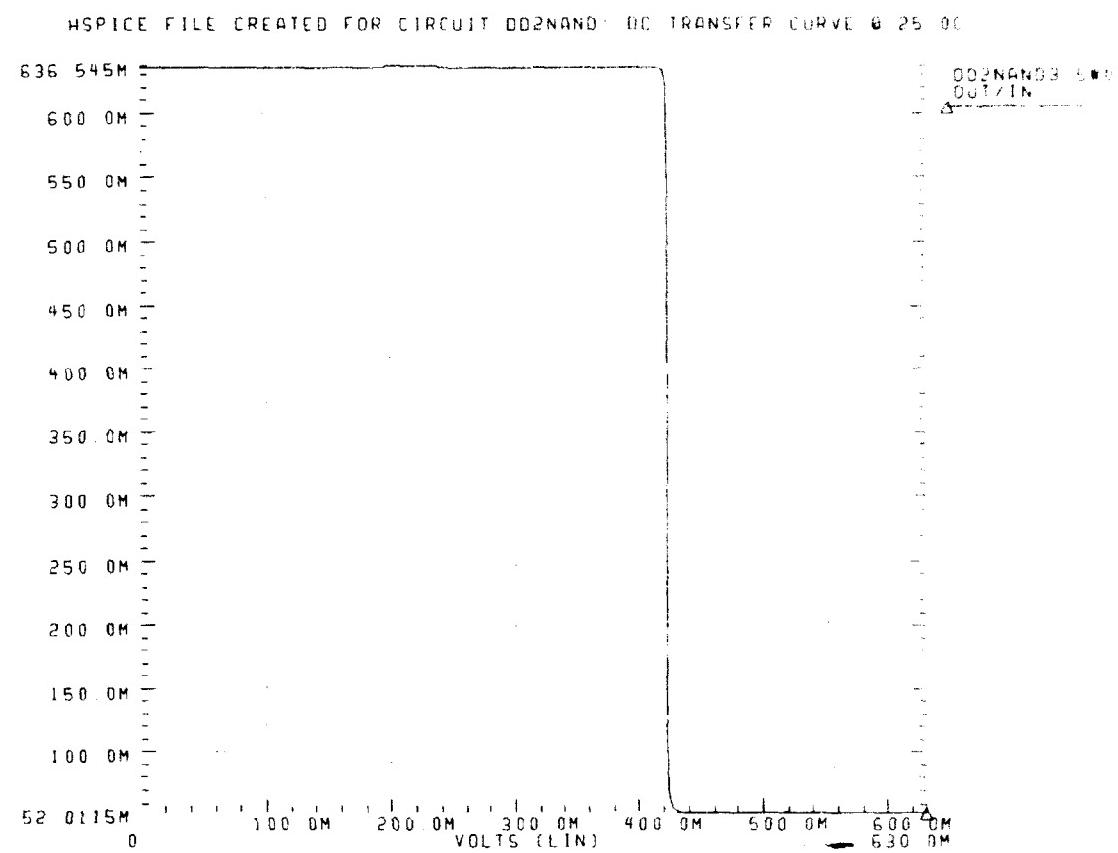


Figure 4.29 DD2NAND DC Transfer Curve at 25.0C

The DC transfer characteristic of the DD2NAND logic gate operating at a temperature of 85.0C is shown in Figure 4.30 on page 41.

HSPICE FILE CREATED FOR CIRCUIT DD2NAND DC TRANSFER CURVE @ 85.0C

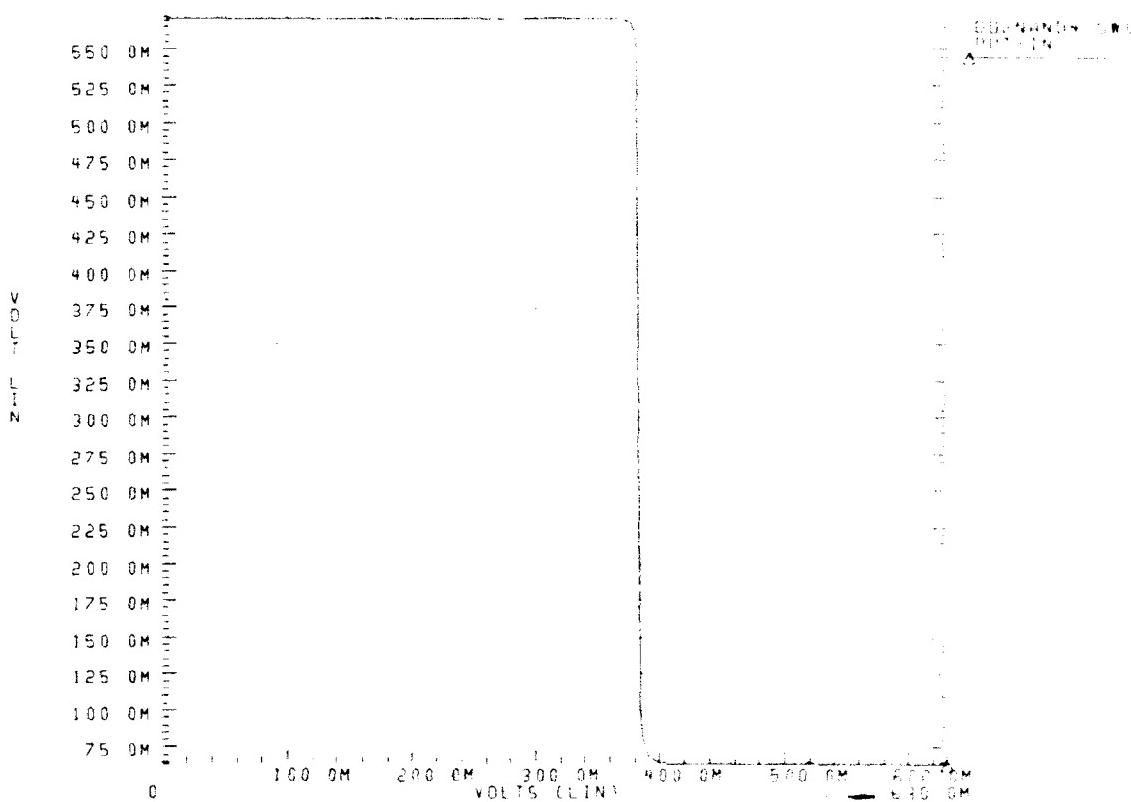


Figure 4.30 DD2NAND DC Transfer Curve at 85.0C

7. DCFL 3-input NAND Gate (DD3NAND)

A DD3NAND logic gate is constructed using the DeMorgan equivalent of a D3NOR with three DINVs on its inputs and one DINV on its output. The end result is a DCFL 3-input NAND gate and Figure 4.31 on page 41 presents the DD3NAND schematic and logical equivalence.

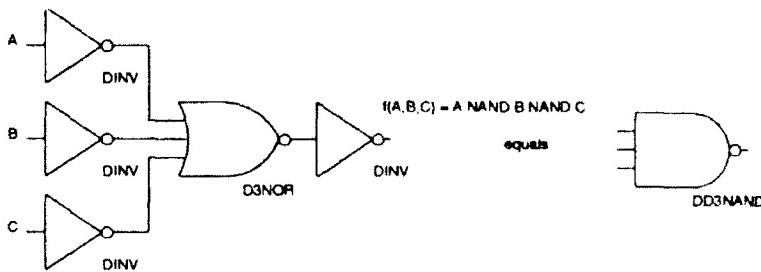


Figure 4.31 DD3NAND Schematic and Logical Equivalence

The transient analysis and power dissipation of the DD3NAND operating at a temperature of 25.0C is shown in Figure 4.32 on page 42. See "Listing File for DD3NAND Transient Analysis @ 25.0C" of Appendix A on page 265.

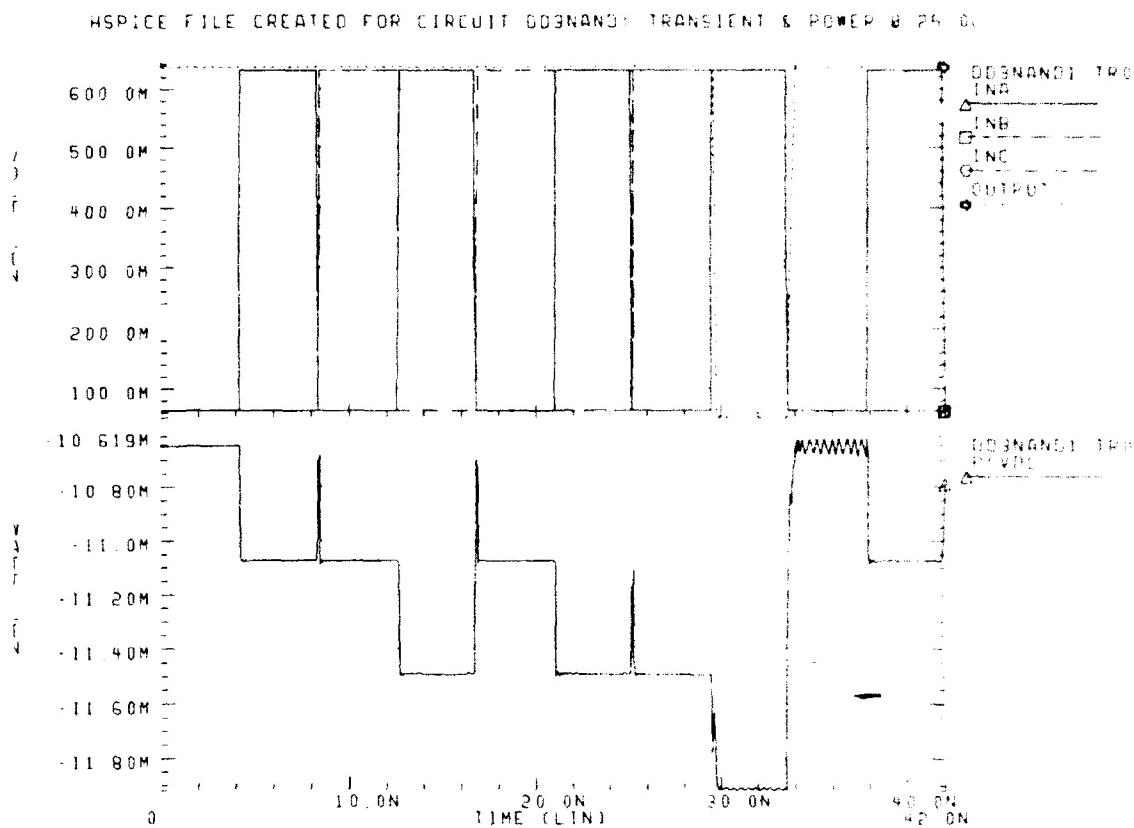


Figure 4.32 DD3NAND HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the DD3NAND operating at a temperature of 85.0C is shown in Figure 4.33 on page 43.

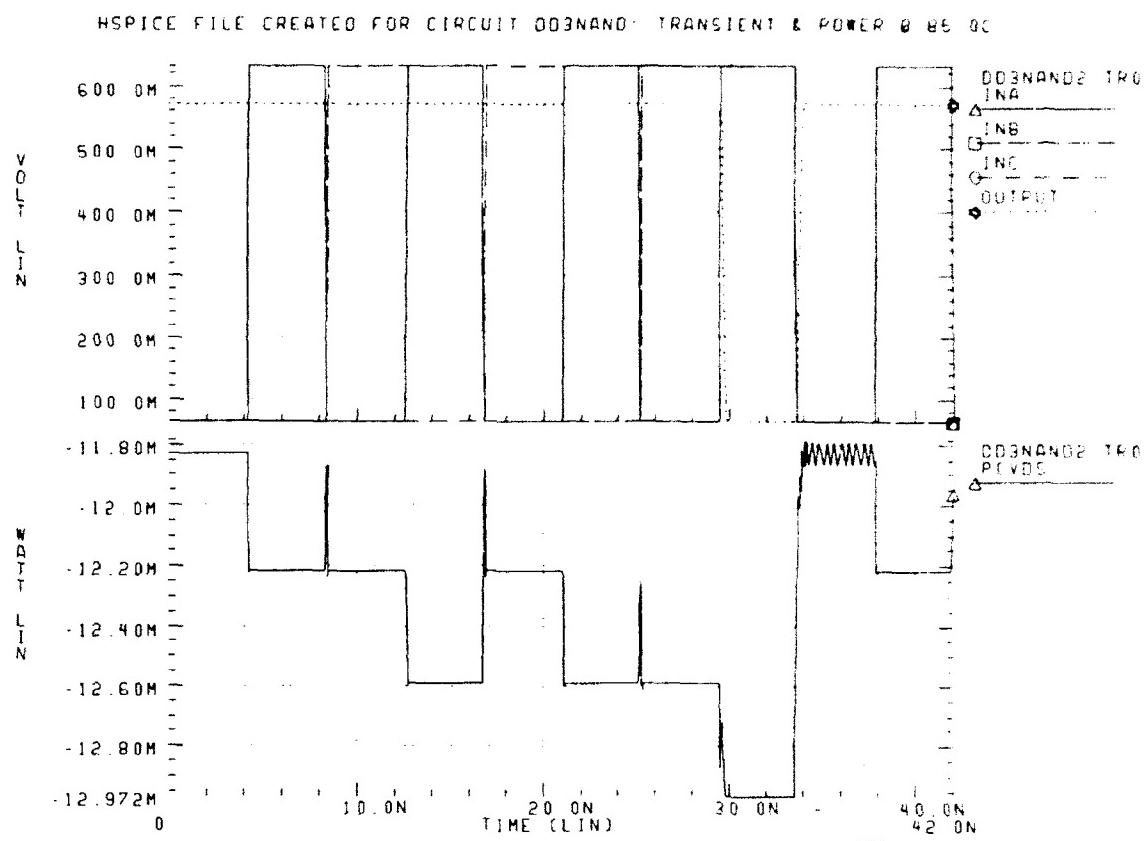


Figure 4.33 DD3NAND HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the DD3NAND logic gate operating at a temperature of 25.0C is shown in Figure 4.34 on page 44.

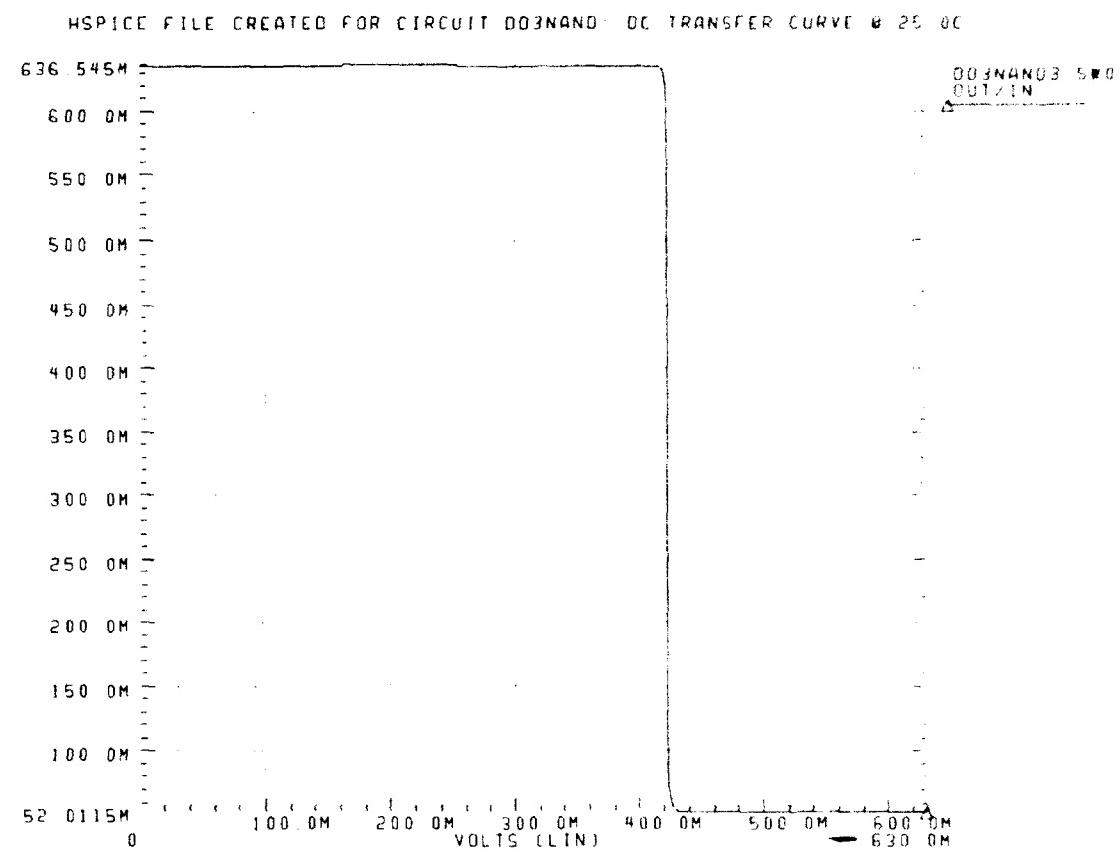


Figure 4.34 DD3NAND DC Transfer Curve at 25.0C

The DC transfer characteristic of the DD3NAND logic gate operating at a temperature of 85.0C is shown in Figure 4.35 on page 45.

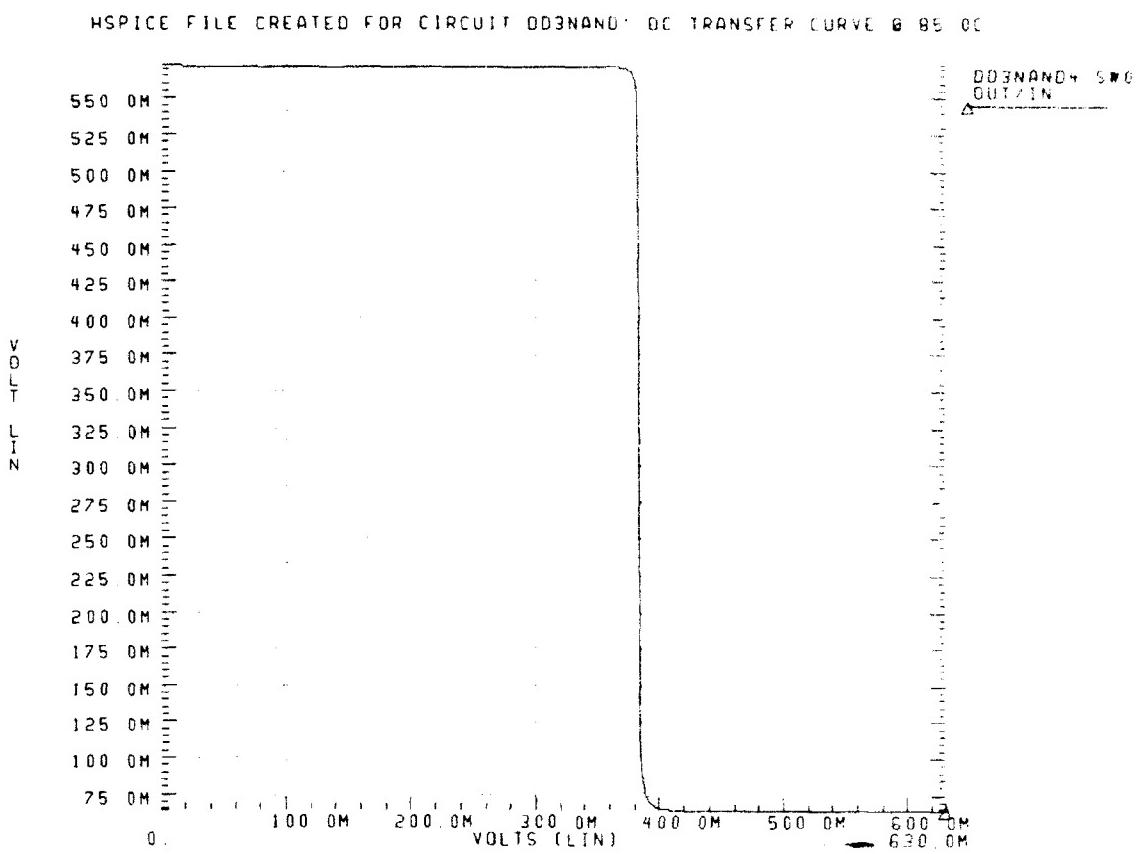


Figure 4.35 DD3NAND DC Transfer Curve at 85.0C

8. DCFL 2-input AND Gate (DD2AND)

A DD2AND logic gate is constructed using the DeMorgan equivalent of a D2NOR with two DINVs on its inputs. The end result is a DCFL 2-input AND gate and Figure 4.36 on page 45 presents the DD2AND schematic and logical equivalence.

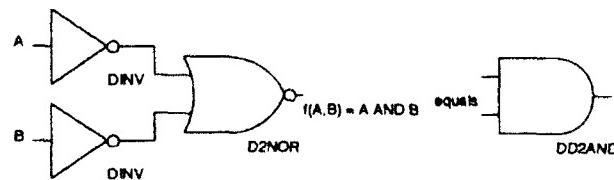


Figure 4.36 DD2AND Schematic and Logical Equivalence

The transient analysis and power dissipation of the DD2AND operating at a temperature of 25.0C is shown in Figure 4.37 on page 46.

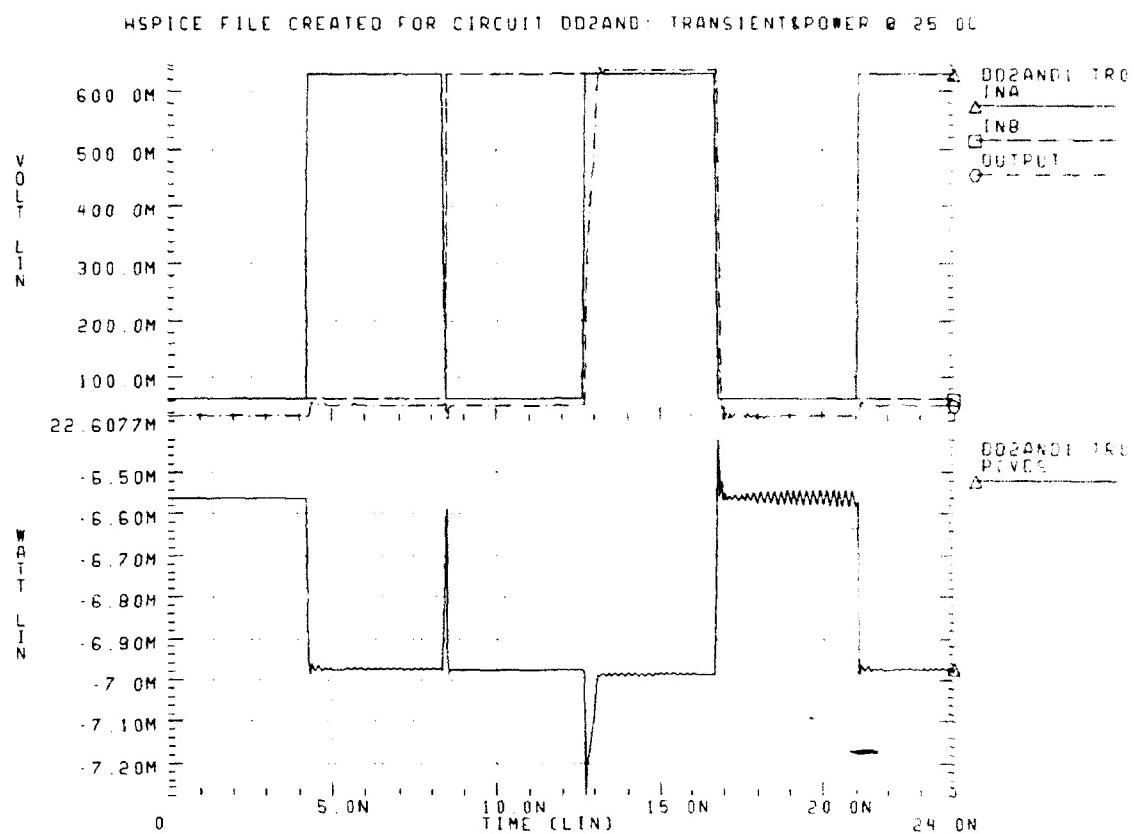


Figure 4.37 DD2AND HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the DD2AND operating at a temperature of 85.0C is shown in Figure 4.38 on page 47.

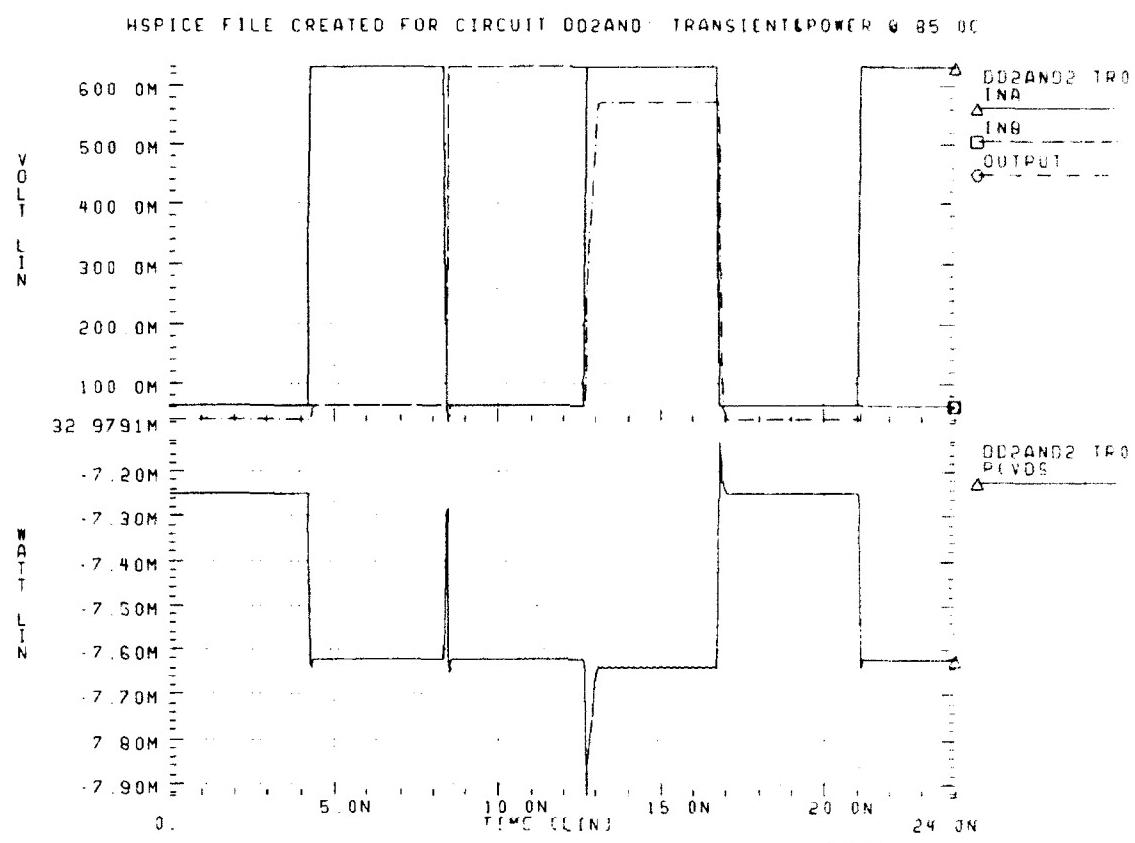


Figure 4.38 DD2AND HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the DD2AND logic gate operating at a temperature of 25.0C is shown in Figure 4.39 on page 48.

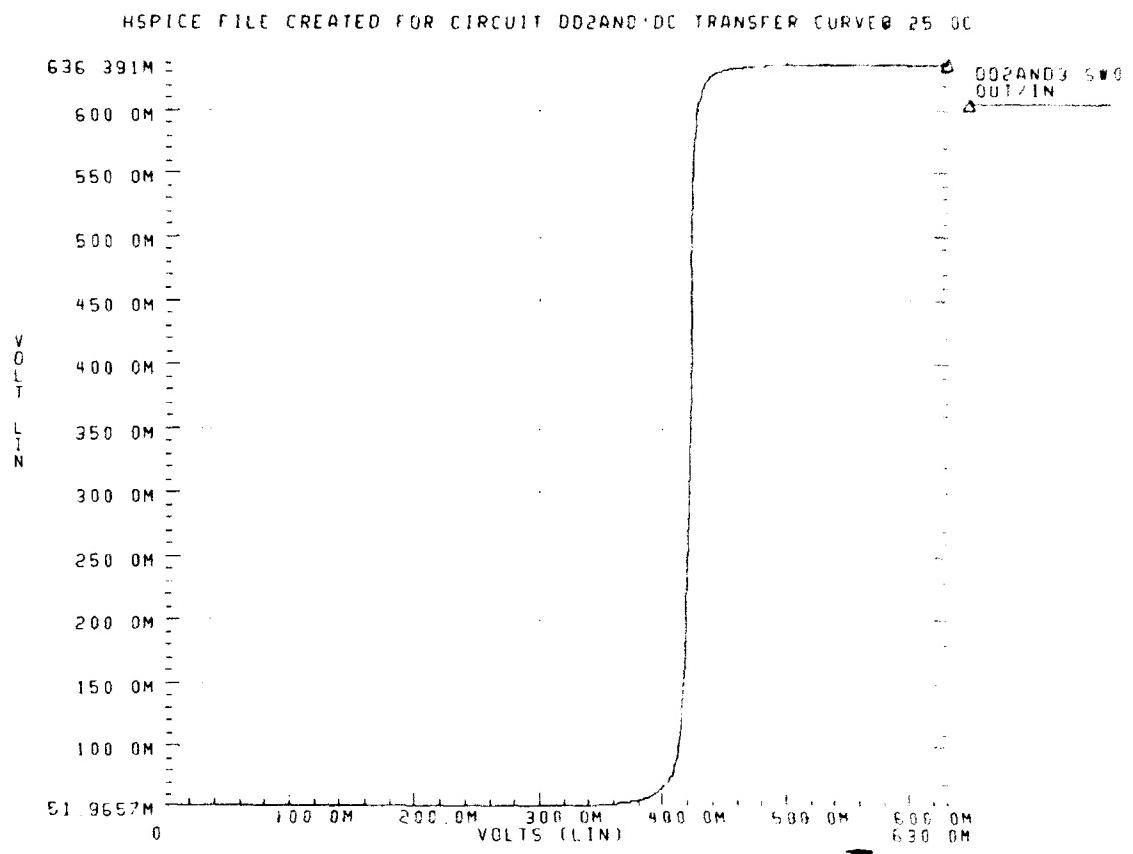


Figure 4.39 DD2AND DC Transfer Curve at 25.0C

The DC transfer characteristic of the DD2AND logic gate operating at a temperature of 85.0C is shown in Figure 4.40 on page 49.

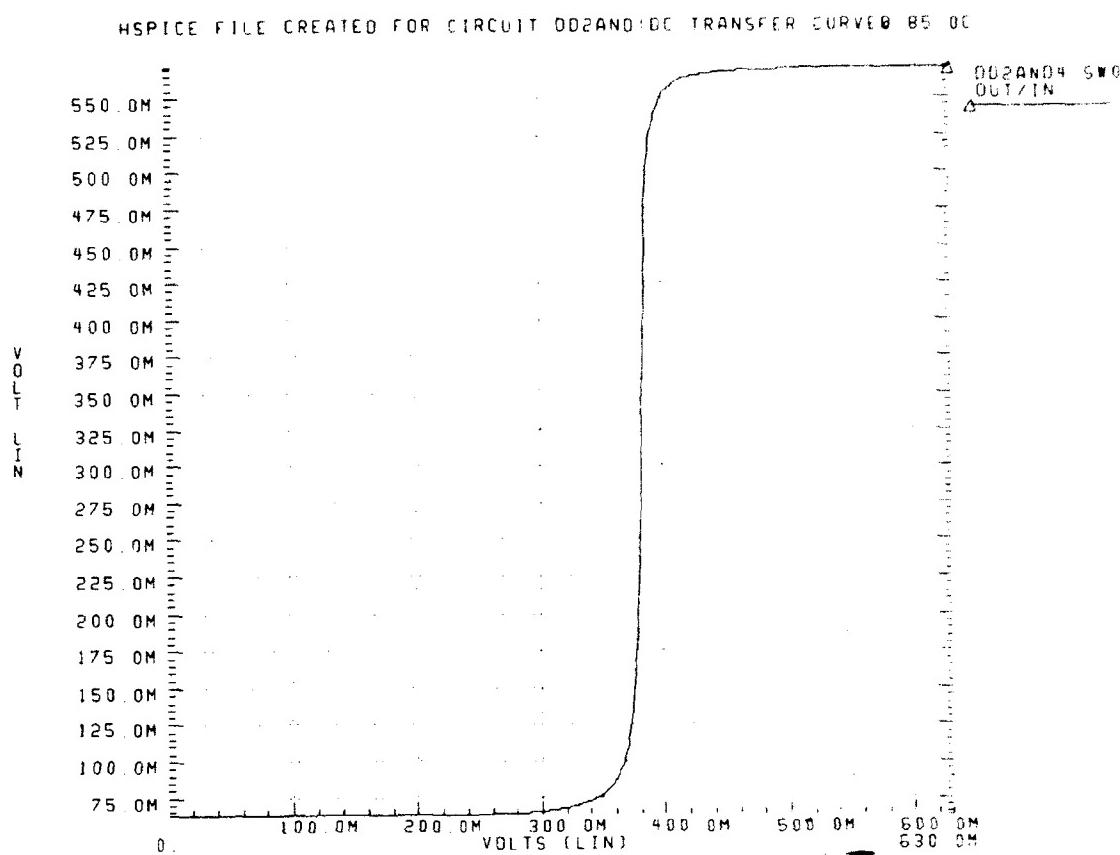


Figure 4.40 DD2AND DC Transfer Curve at 85.0C

9. DCFL 3-input AND Gate (DD3AND)

A DD3AND logic gate is constructed using the DeMorgan equivalent of a D3NOR with three DINVs on its inputs. The end result is a DCFL 3-input AND gate and Figure 4.41 on page 49 presents the DD3AND schematic and logical equivalence.

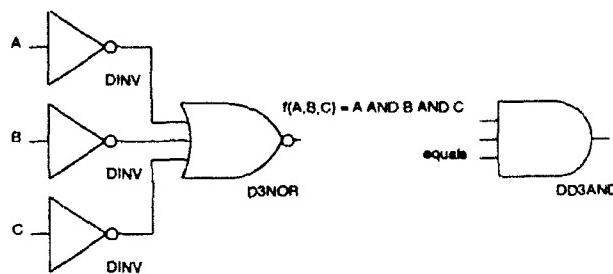


Figure 4.41 DD3AND Schematic and Logical Equivalence

The transient analysis and power dissipation of the DD3AND operating at a temperature of 25.0C is shown in Figure 4.42 on page 50.

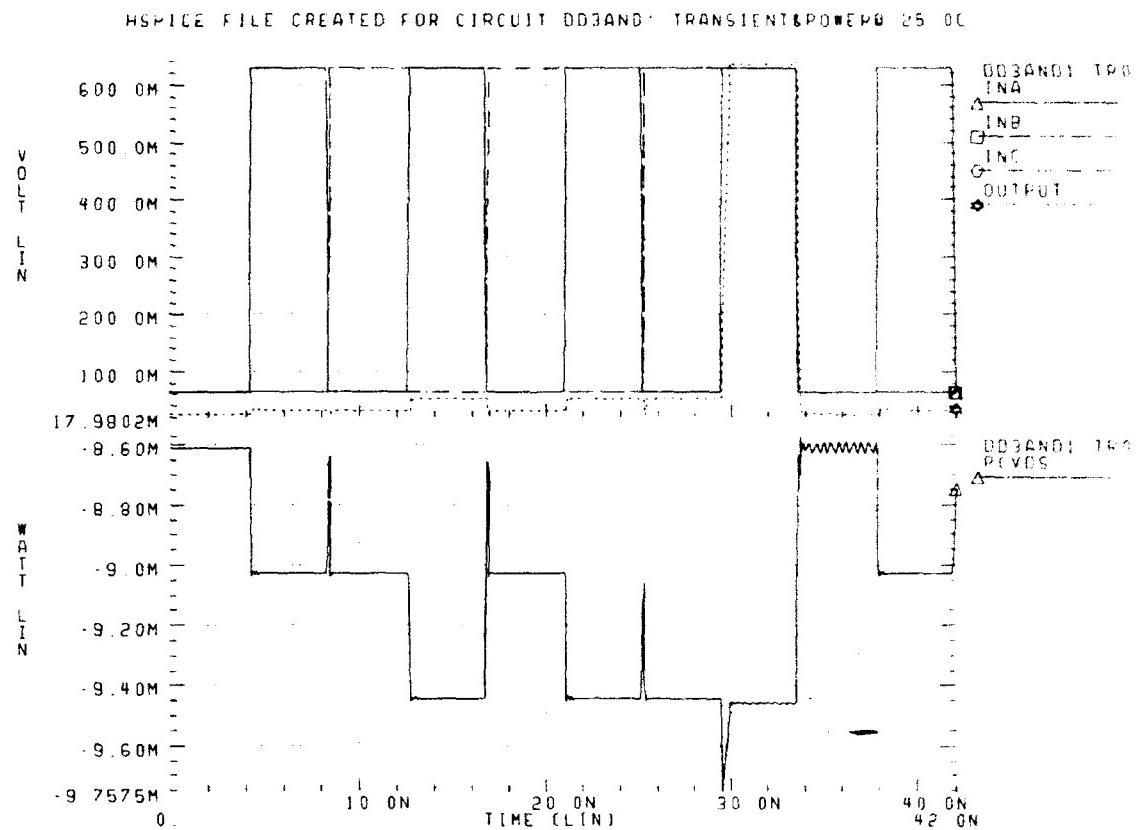


Figure 4.42 DD3AND HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the DD3AND operating at a temperature of 85.0C is shown in Figure 4.43 on page 51.

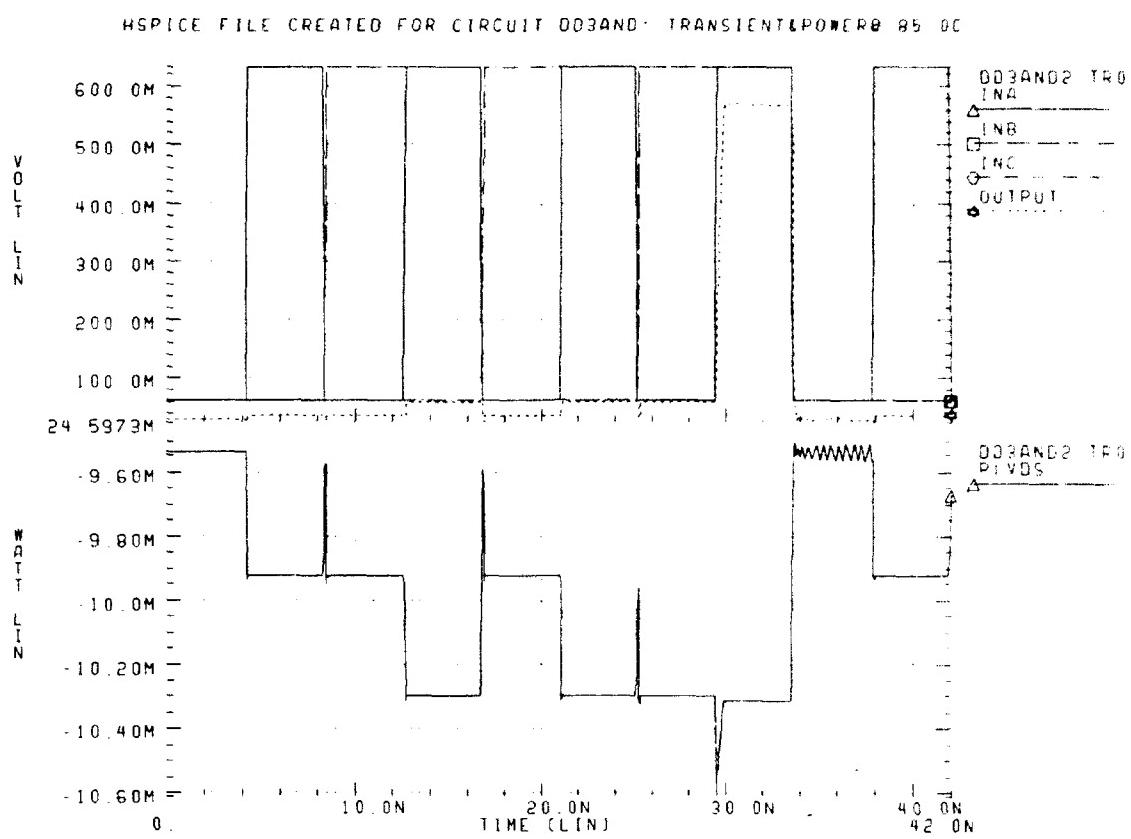


Figure 4.43 DD3AND HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the DD3AND logic gate operating at a temperature of 25.0C is shown in Figure 4.44 on page 52.

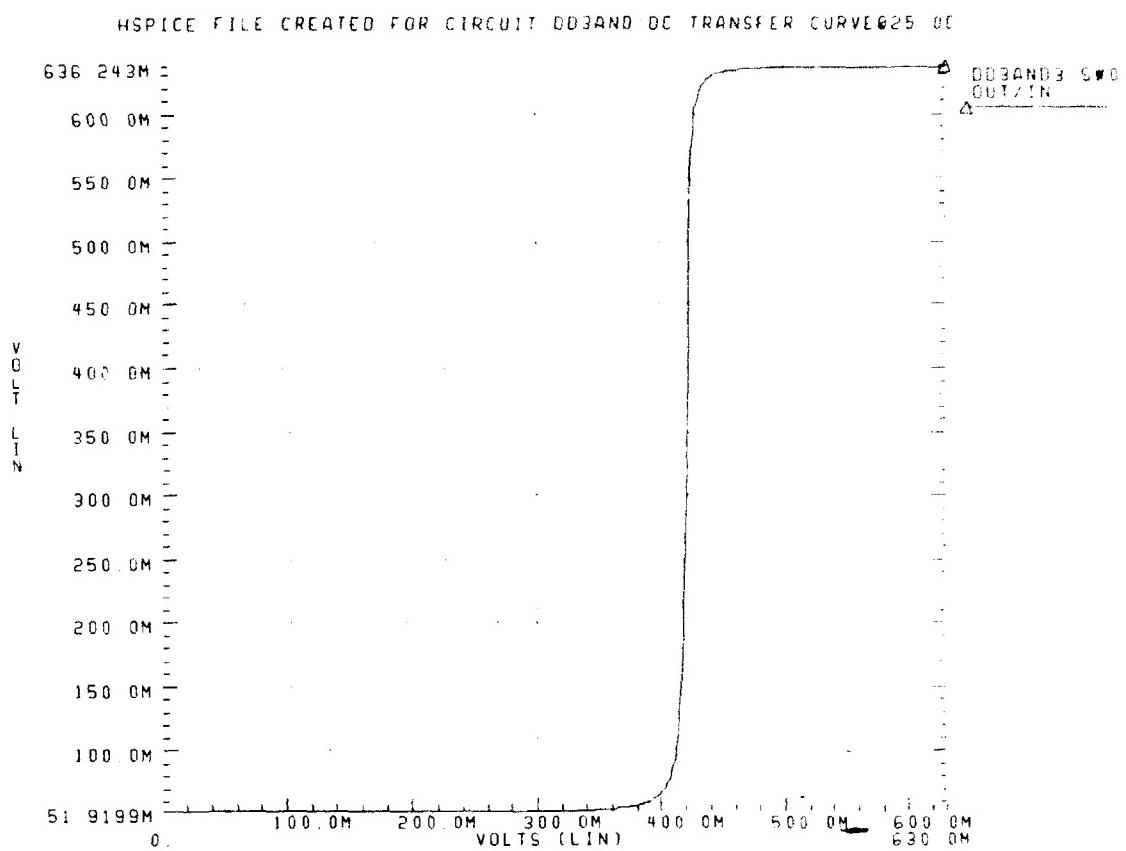


Figure 4.44 DD3AND DC Transfer Curve at 25.0C

The DC transfer characteristic of the DD3AND logic gate operating at a temperature of 85.0C is shown in Figure 4.45 on page 53.

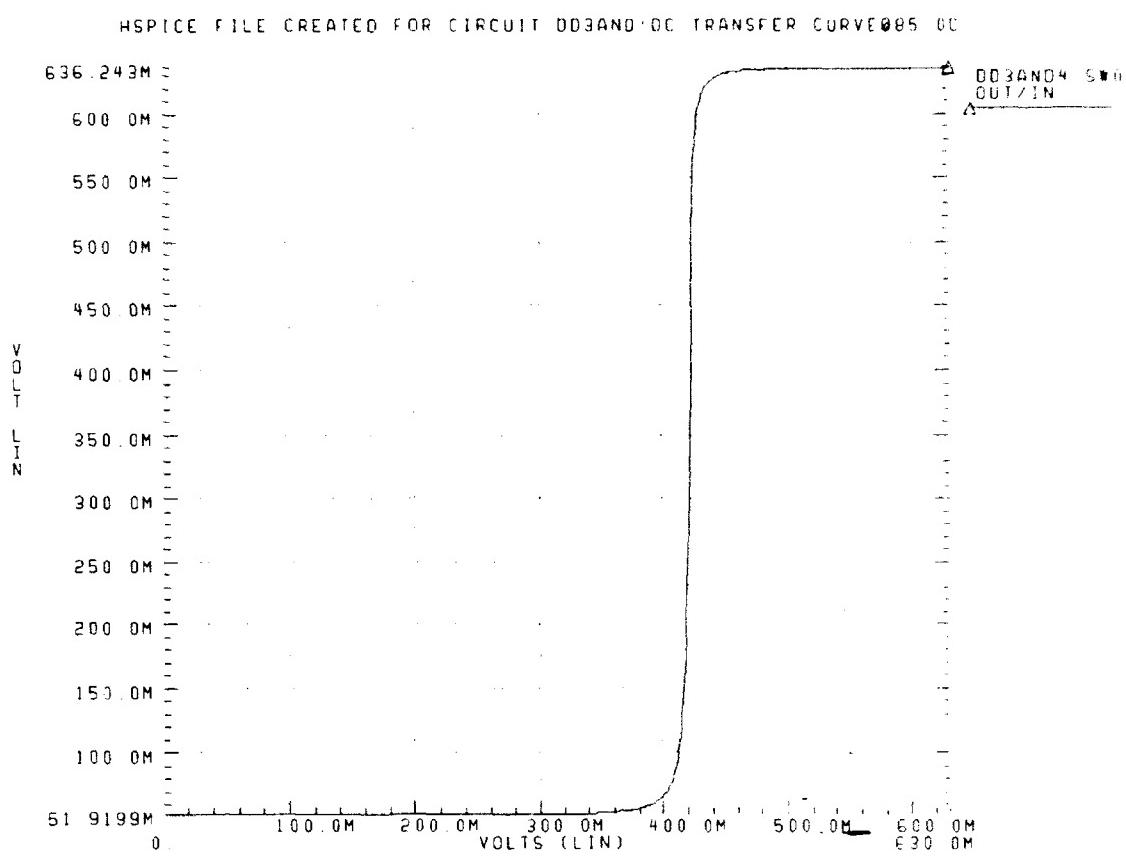


Figure 4.45 DD3AND DC Transfer Curve at 85.0C

10. DCFL 4-input AND Gate (DD4AND)

A DD4AND logic gate is constructed using the DeMorgan equivalent of a D4NOR with four DINVs on its inputs. The end result is a DCFL 4-input AND gate and Figure 4.46 on page 54 presents the DD4AND schematic and logical equivalence.

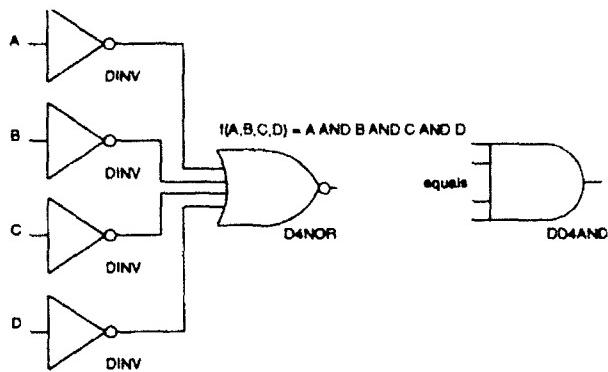


Figure 4.46 DD4AND Schematic and Logical Equivalence

The transient analysis and power dissipation of the DD4AND operating at a temperature of 25.0C is shown in Figure 4.47 on page 54. See "Listing File for DD4AND Transient Analysis @ 25.0C" of Appendix A on page 268.

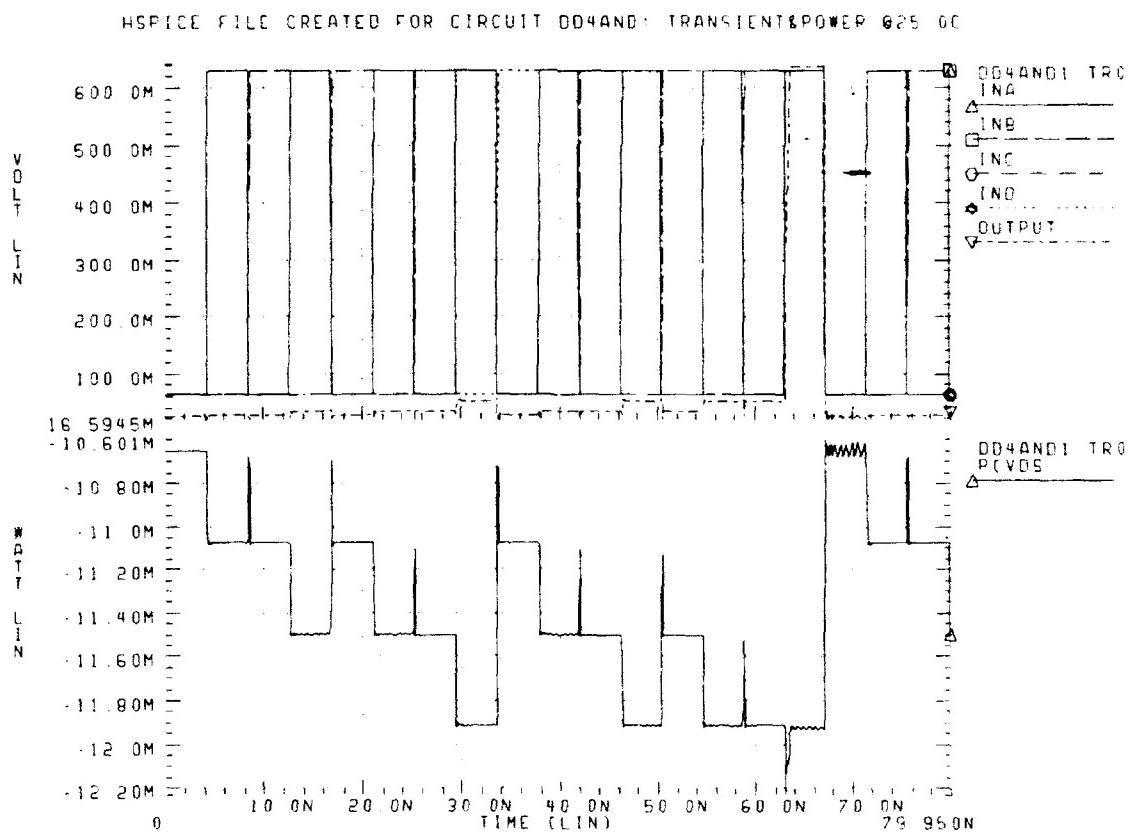


Figure 4.47 DD4AND HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the DD4AND operating at a temperature of 85.0C is shown in Figure 4.48 on page 55.

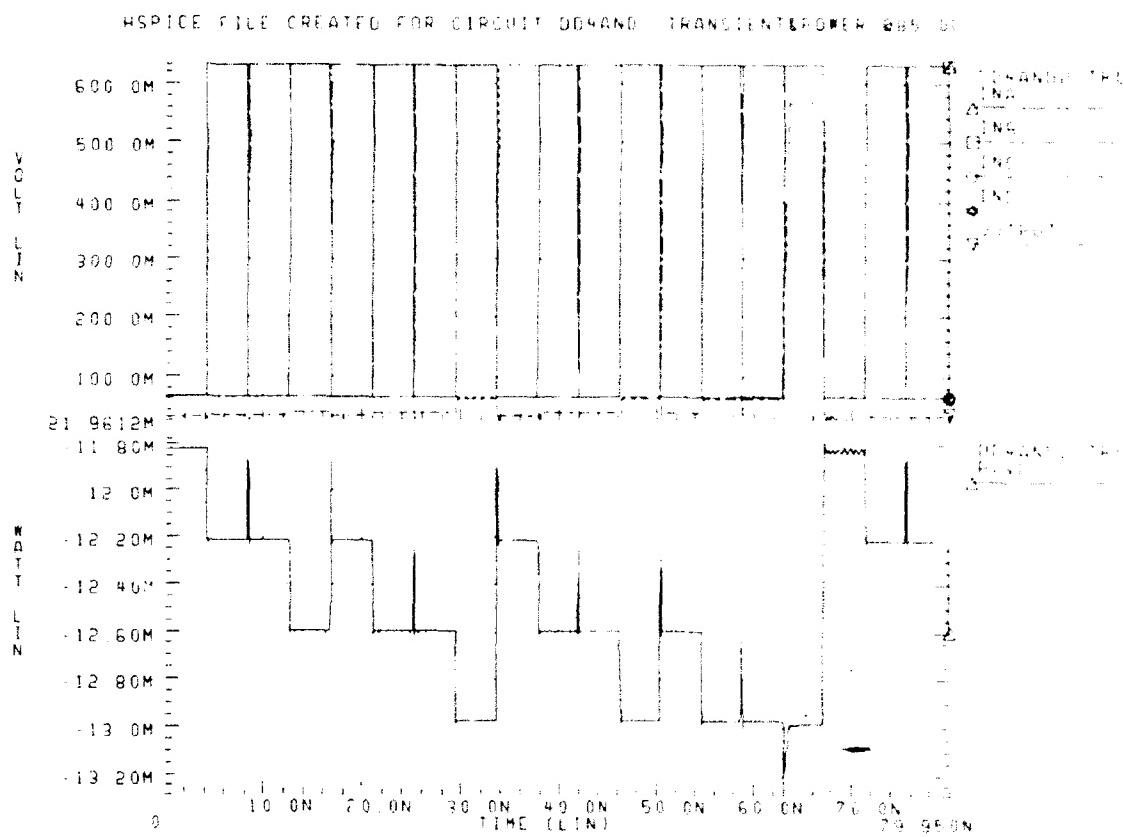


Figure 4.48 DD4AND HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the DD4AND logic gate operating at a temperature of 25.0C is shown in Figure 4.49 on page 56.

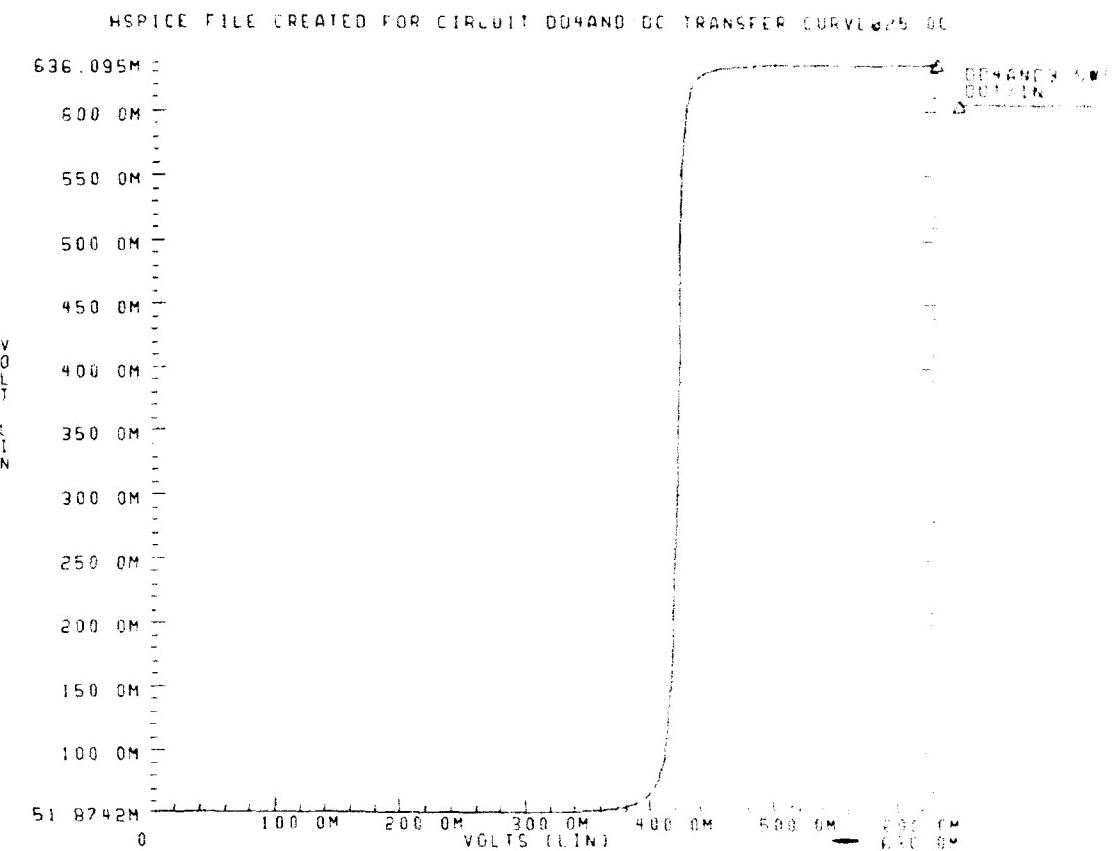


Figure 4.49 DD4AND DC Transfer Curve at 25.0C

The DC transfer characteristic of the DD4AND logic gate operating at a temperature of 85.0C is shown in Figure 4.50 on page 57.

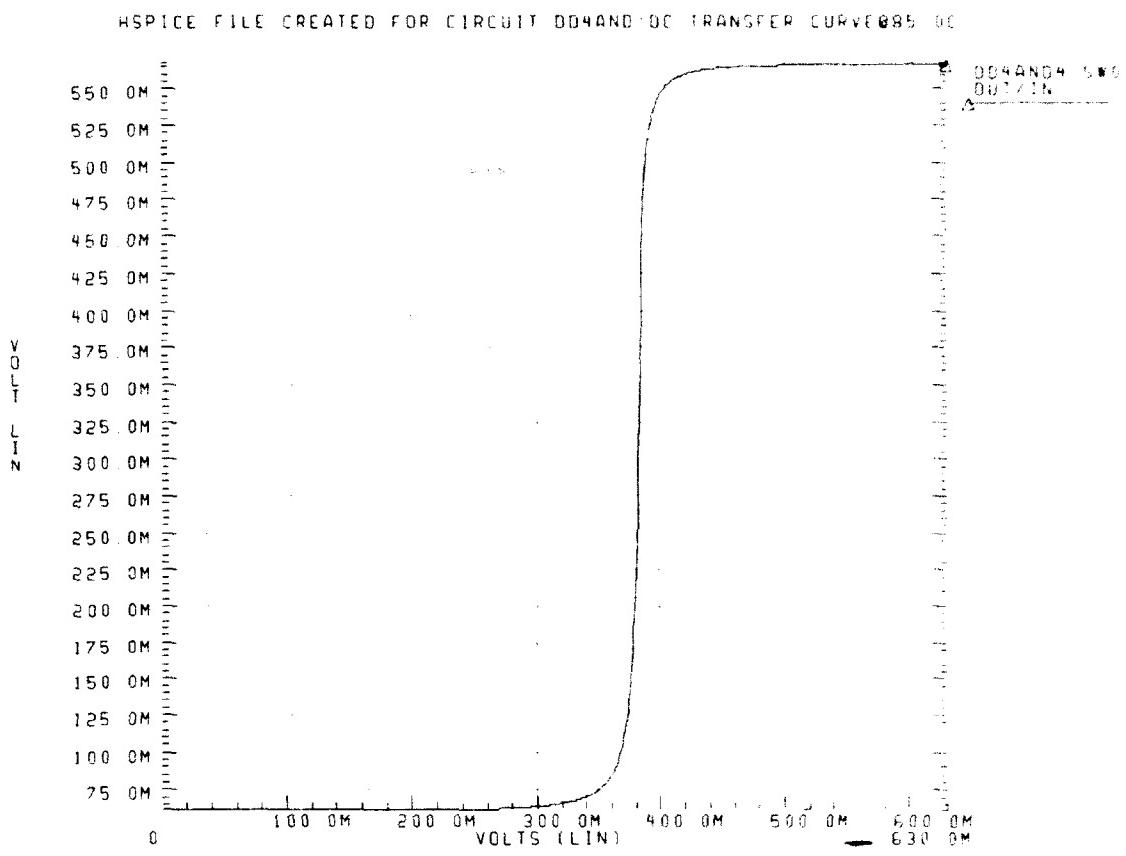


Figure 4.50 DD4AND DC Transfer Curve at 85.0C

11. DCFL 2-input OR Gate (DD2OR)

A DD2OR logic gate is constructed using the DeMorgan equivalent of a D2NOR with a single DINV on its input. The end result is a DCFL 2-input OR gate and Figure 4.51 on page 57 presents the DD2OR schematic and logical equivalence.

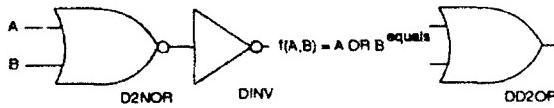


Figure 4.51 DD2OR Schematic And Logical Equivalence

The transient analysis and power dissipation of the DD2OR operating at a temperature of 25.0C is shown in Figure 4.52 on page 58.

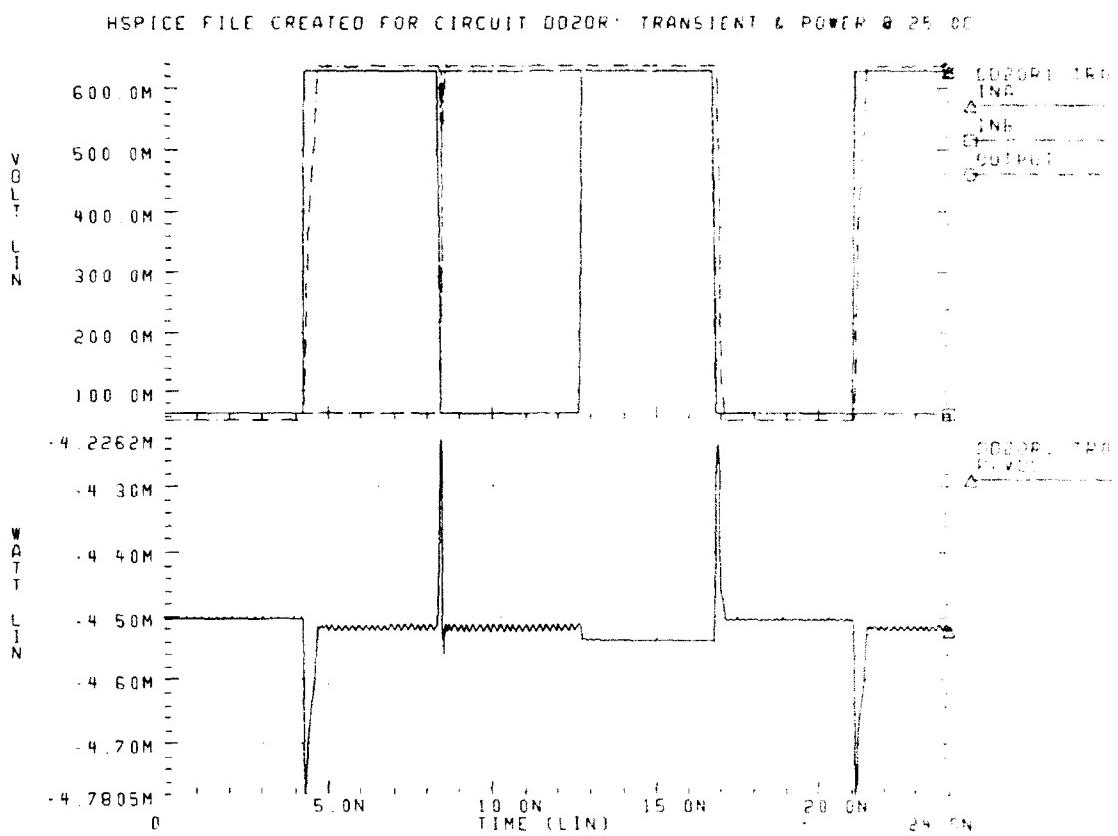


Figure 4.52 DD2OR HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the DD2OR operating at a temperature of 85.0C is shown in Figure 4.53 on page 59.

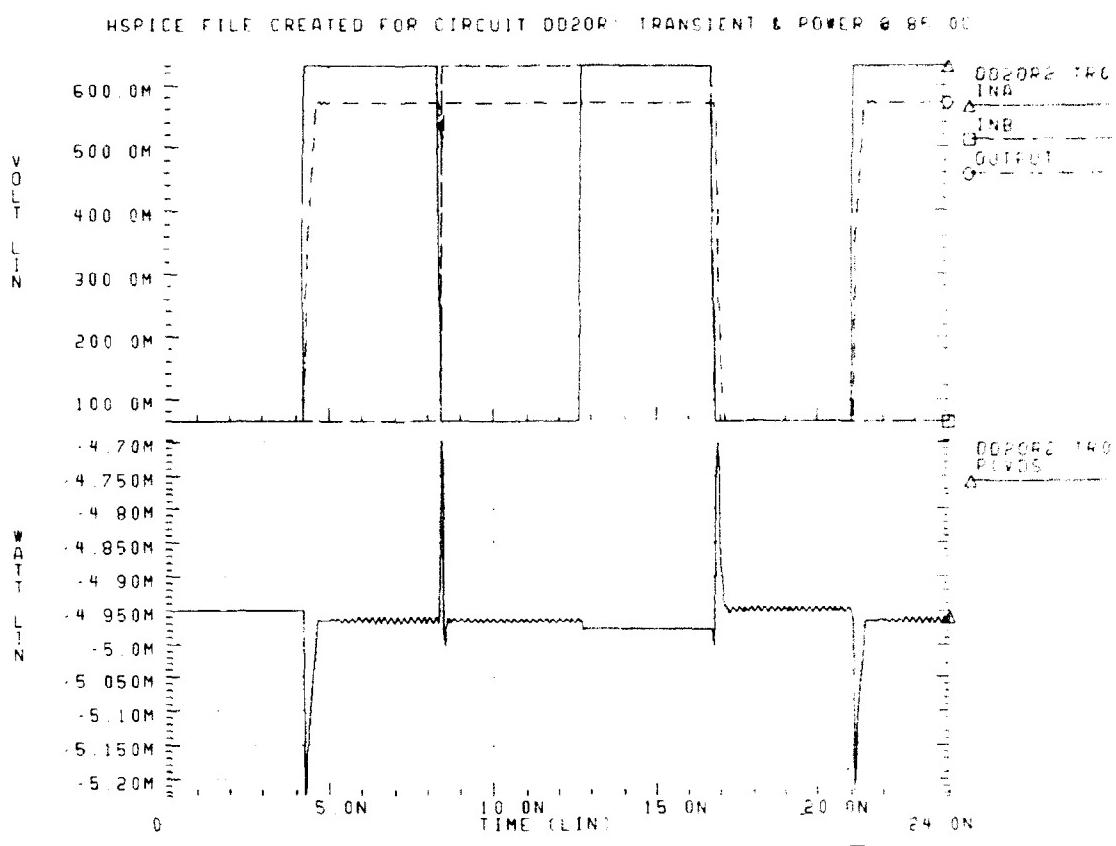


Figure 4.53 DD2OR HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the DD2OR logic gate operating at a temperature of 25.0C is shown in Figure 4.54 on page 60.

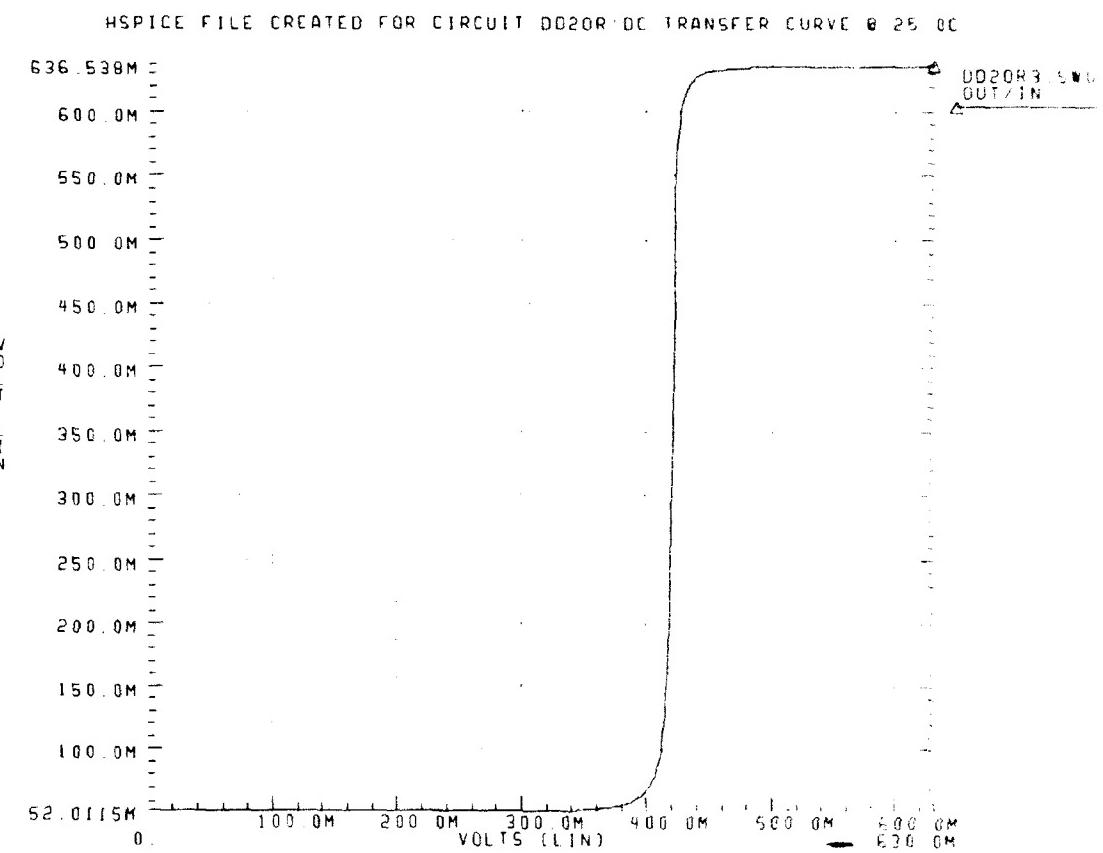


Figure 4.54 DD2OR DC Transfer Curve at 25.0C

The DC transfer characteristic of the DD2OR logic gate operating at a temperature of 85.0C is shown in Figure 4.55 on page 61.

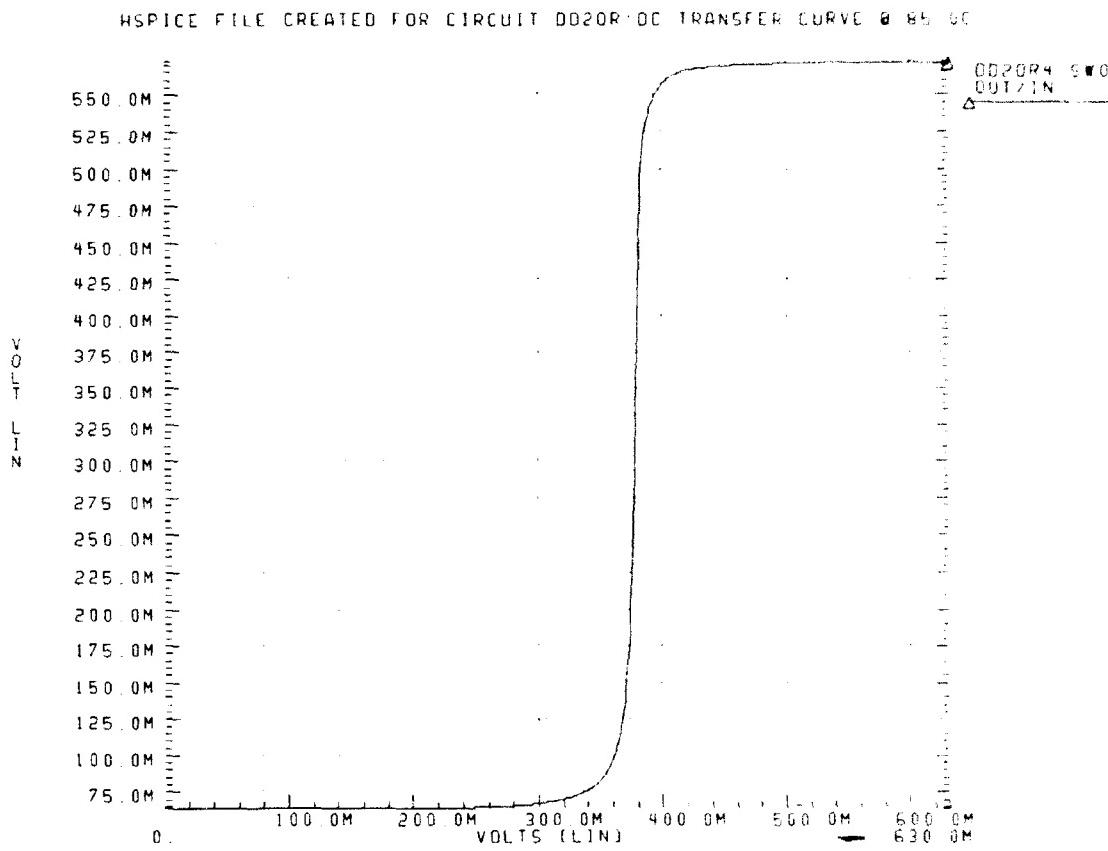


Figure 4.55 DD2OR DC Transfer Curve at 85.0C

12. DCFL 3-input OR Gate (DD3OR)

A DD3OR logic gate is constructed using the DeMorgan equivalent of a D3NOR with a single DINV on its input. The end result is a DCFL 3-input OR gate and Figure 4.56 on page 61 presents the DD3OR schematic and logical equivalence.

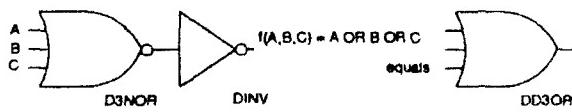


Figure 4.56 DD3OR Schematic And Logical Equivalence

The transient analysis and power dissipation of the DD3OR operating at a temperature of 25.0C is shown in Figure 4.57 on page 62.

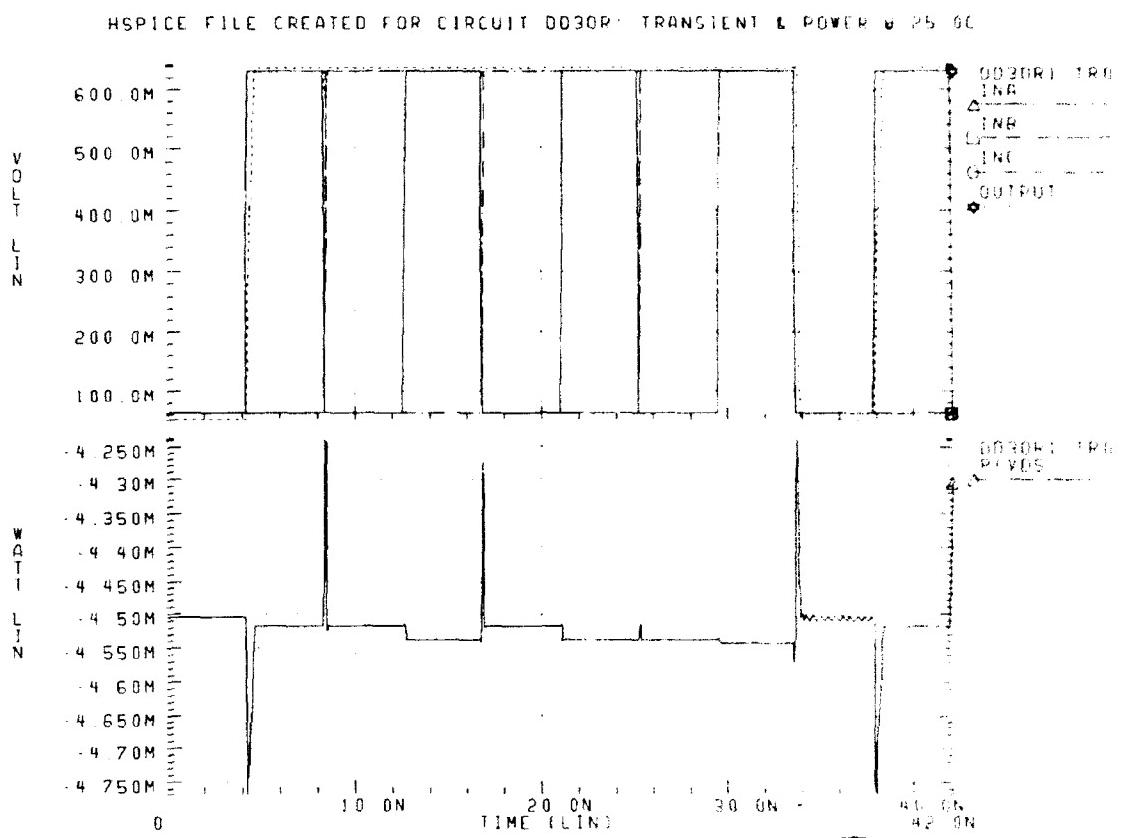


Figure 4.57 DD3OR HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the DD3OR operating at a temperature of 85.0C is shown in Figure 4.58 on page 63.

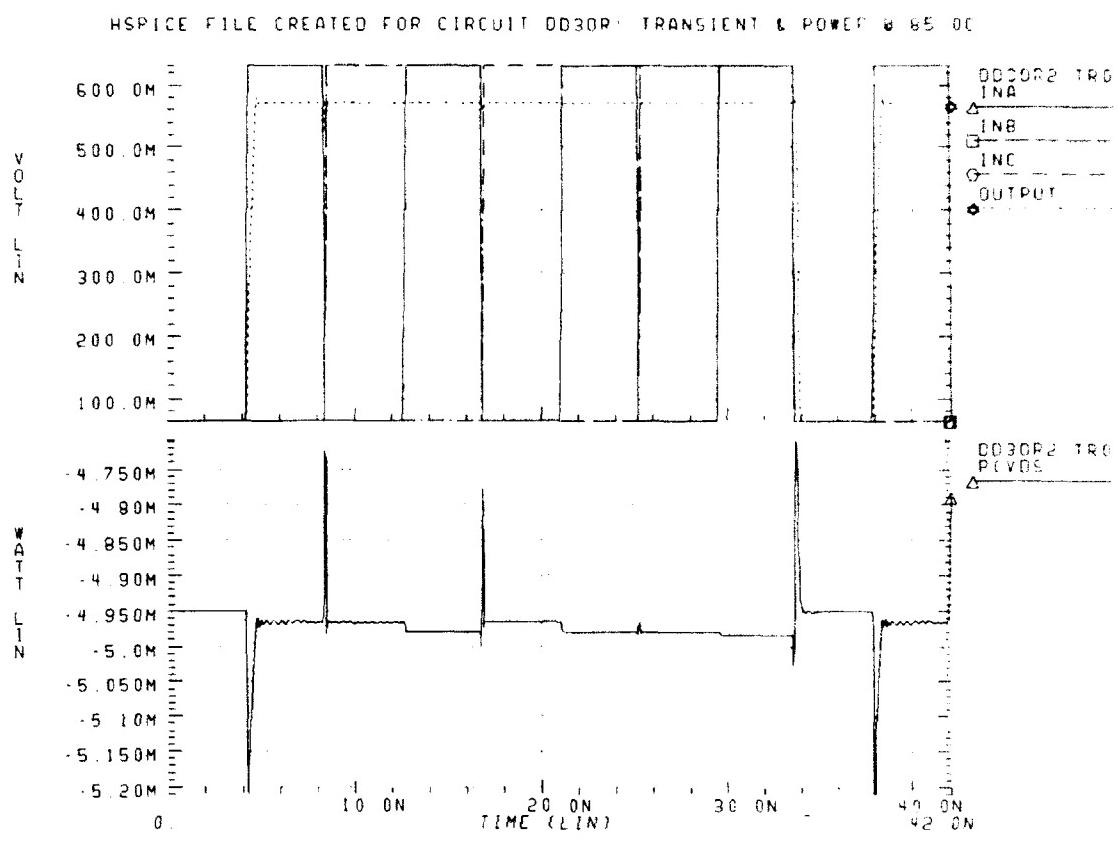


Figure 4.58 DD3OR HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the DD3OR logic gate operating at a temperature of 25.0C is shown in Figure 4.59 on page 64.

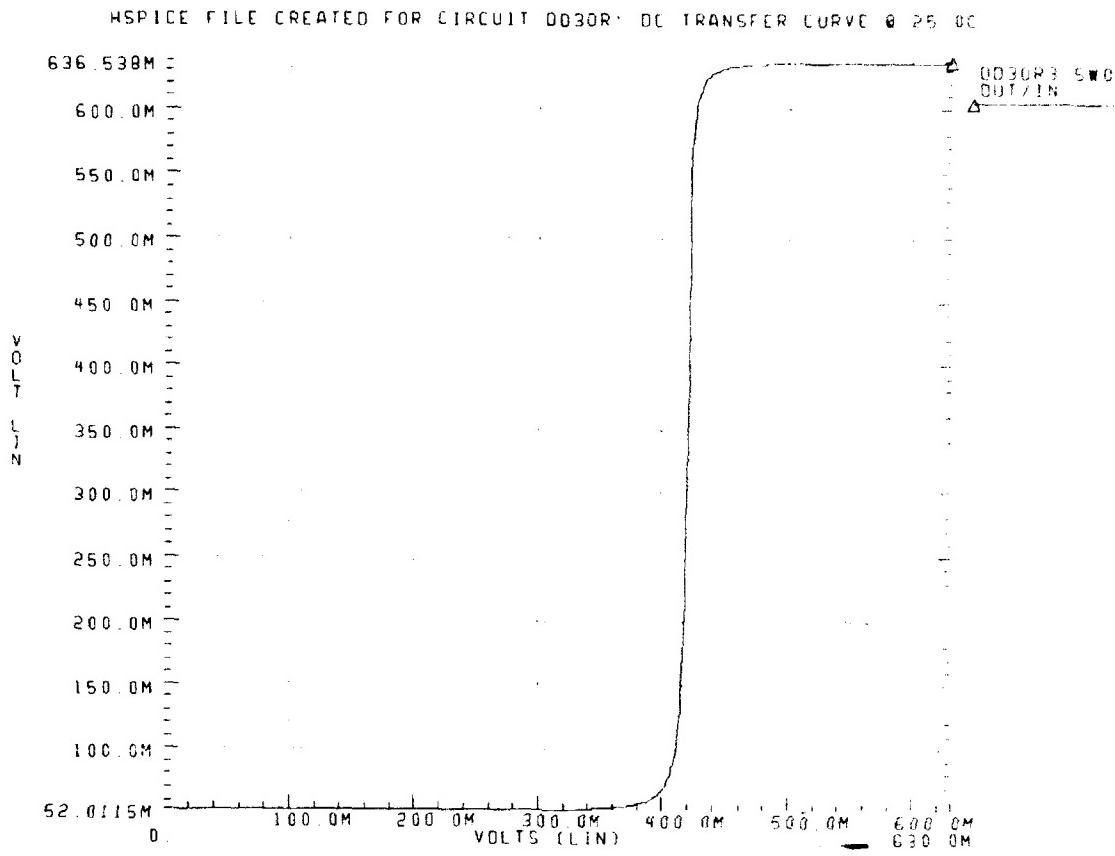


Figure 4.59 DD3OR DC Transfer Curve at 25.0C

The DC transfer characteristic of the DD3OR logic gate operating at a temperature of 85.0C is shown in Figure 4.60 on page 65.

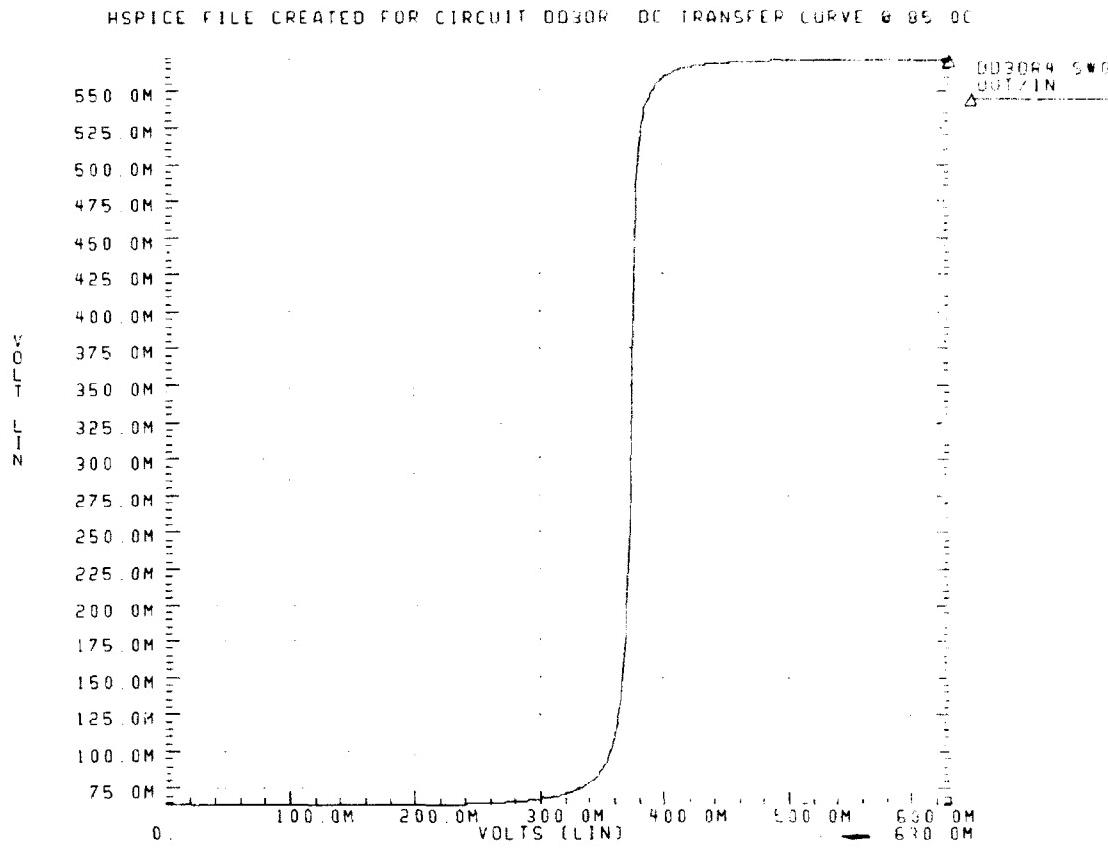


Figure 4.60 DD30OR DC Transfer Curve at 85.0C

13. DCFL 4-input OR Gate (DD4OR)

A DD4OR logic gate is constructed using the DeMorgan equivalent of a D4NOR with a single DINV on its input. The end result is a DCFL 4-input OR gate and Figure 4.61 on page 65 presents the DD4OR schematic and logical equivalence.

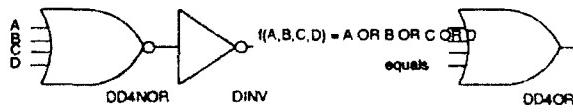


Figure 4.61 DD4OR Schematic And Logical Equivalence

The transient analysis and power dissipation of the DD4OR operating at a temperature of 25.0C is shown in Figure 4.62 on page 66. See "Listing File for DD4OR Transient Analysis @ 25.0C" of Appendix A on page 271.

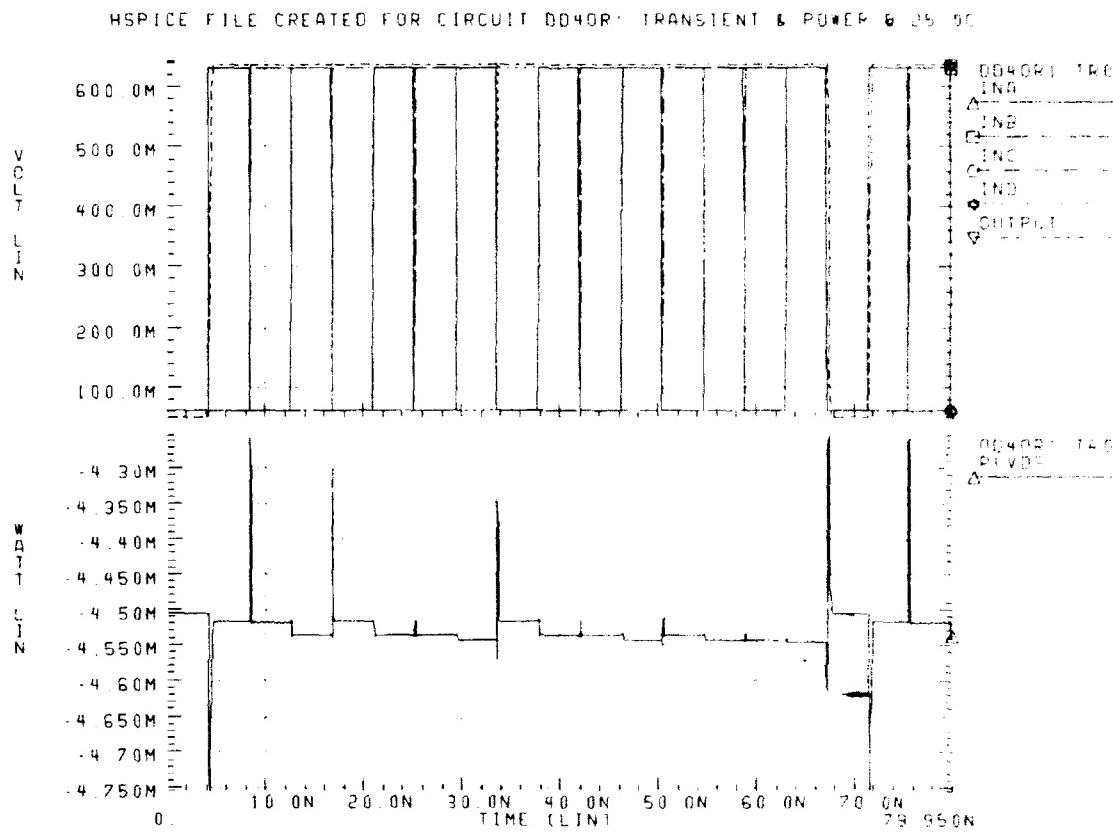


Figure 4.62 DD4OR HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the DD4OR operating at a temperature of 85.0C is shown in Figure 4.63 on page 67.

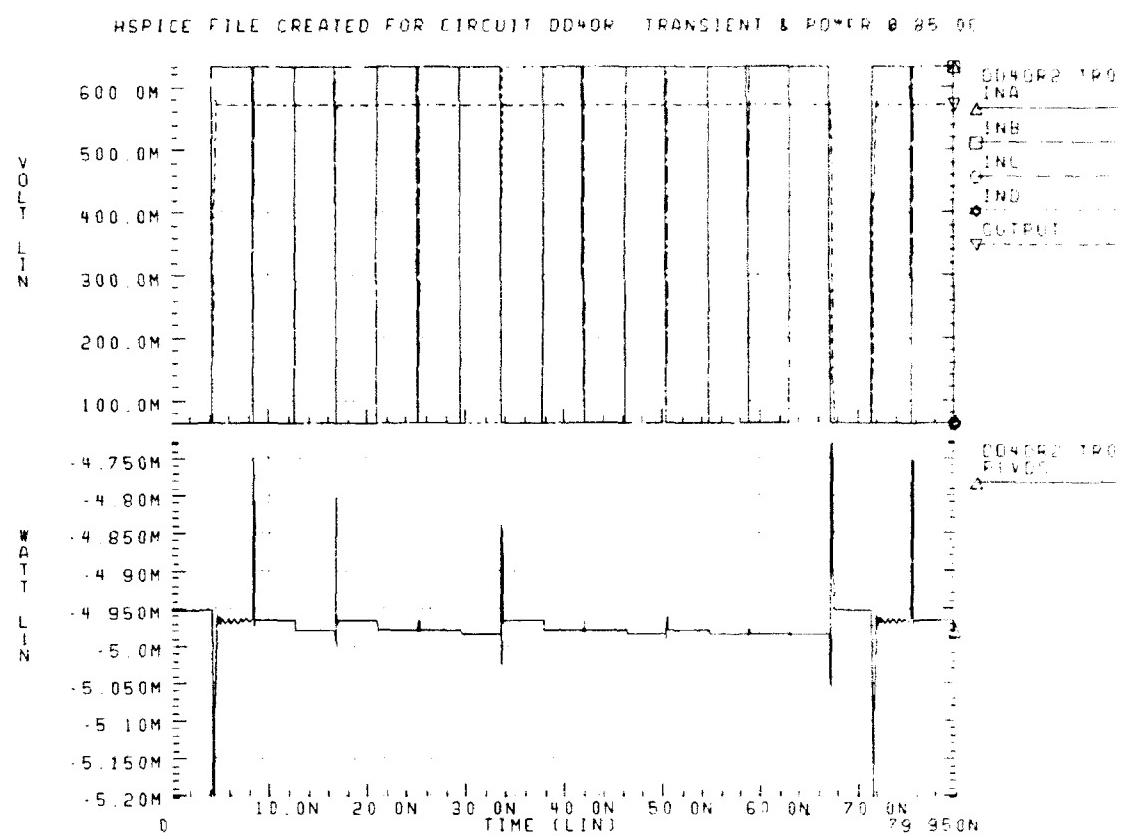


Figure 4.63 DD4OR HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the DD4OR logic gate operating at a temperature of 25.0C is shown in Figure 4.64 on page 68.

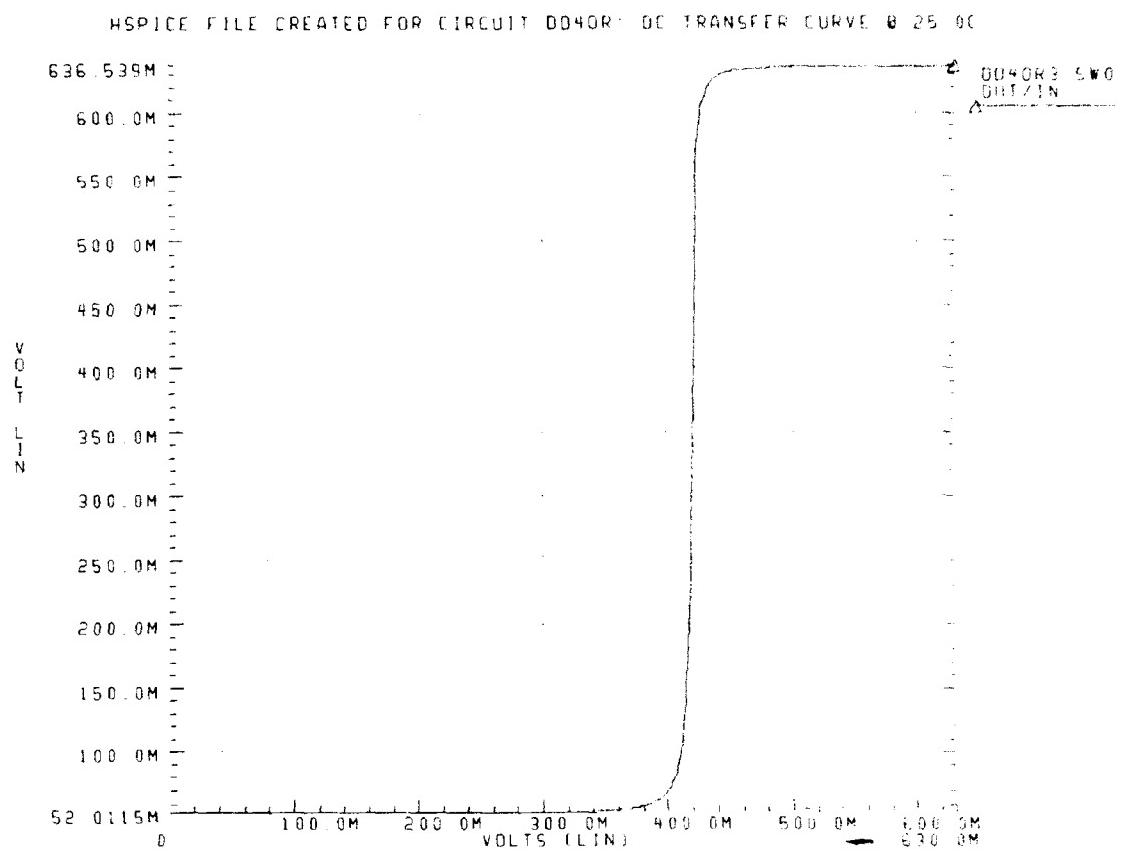


Figure 4.64 DD4OR DC Transfer Curve at 25.0C

The DC transfer characteristic of the DD4OR logic gate operating at a temperature of 85.0C is shown in Figure 4.65 on page 69.

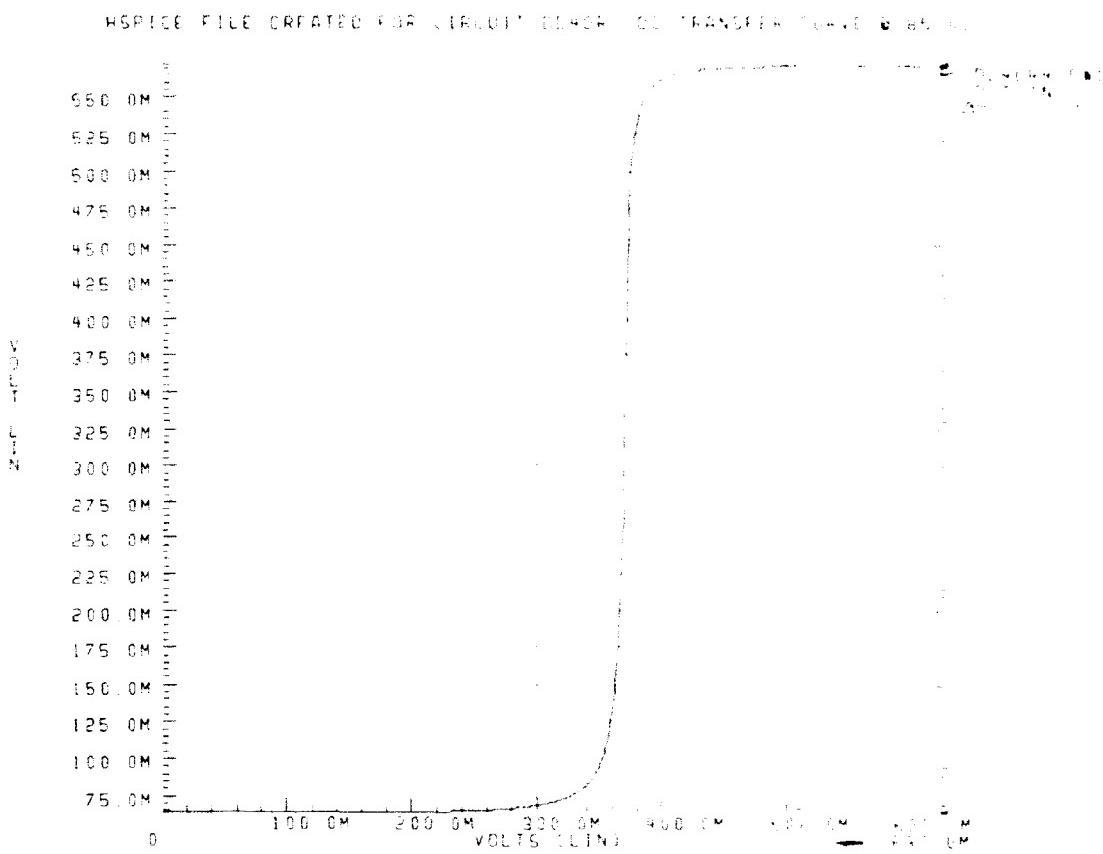


Figure 4.65 DD40R DC Transfer Curve at 85.0C

14. "BIG" DCFL INVERTER (BDINV)

A very fast and powerful DCFL inverter was required for several circuits specifically, DELAY and BS2AND. The sizes of the MESFETs and its associated schematic and logical equivalence are shown in Figure 4.66 on page 69.

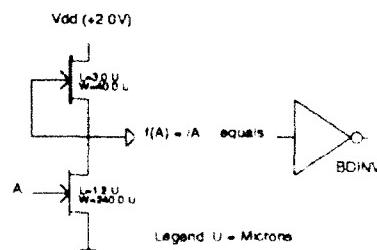


Figure 4.66 BDINV Schematic And Logical Equivalence

The transient analysis and power dissipation of the BDINV operating at a temperature of 25.0C is shown in Figure 4.67 on page 70. Examining Figure 4.67, the "ringing" in the lower (power) graph is believed to be caused by a current surge in the output node. When this logic circuit is used to drive larger circuits for which it was specifically designed, the output node shows no "ringing" because of the dampening factor of the increased load. For an excellent discussion of the device physics, see [Ref. 10:pp. 11-18].

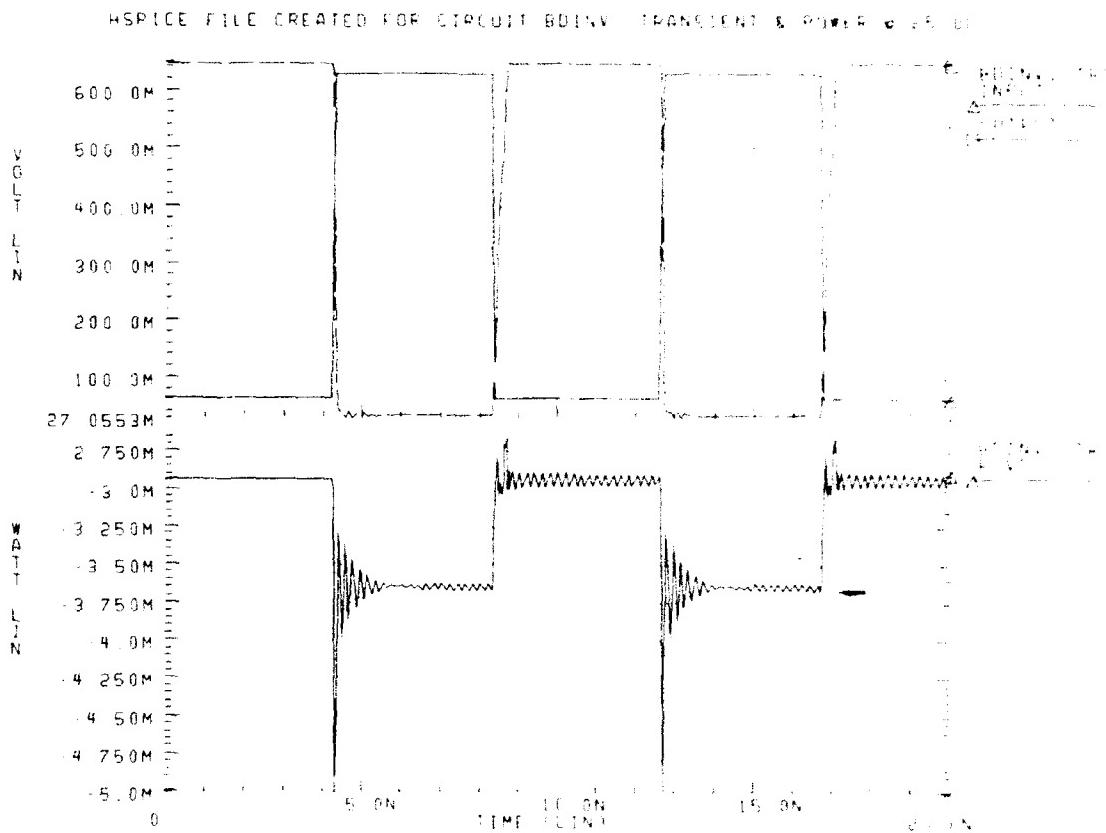


Figure 4.67 BDINV HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the BDINV operating at a temperature of 85.0C is shown in Figure 4.68 on page 71.

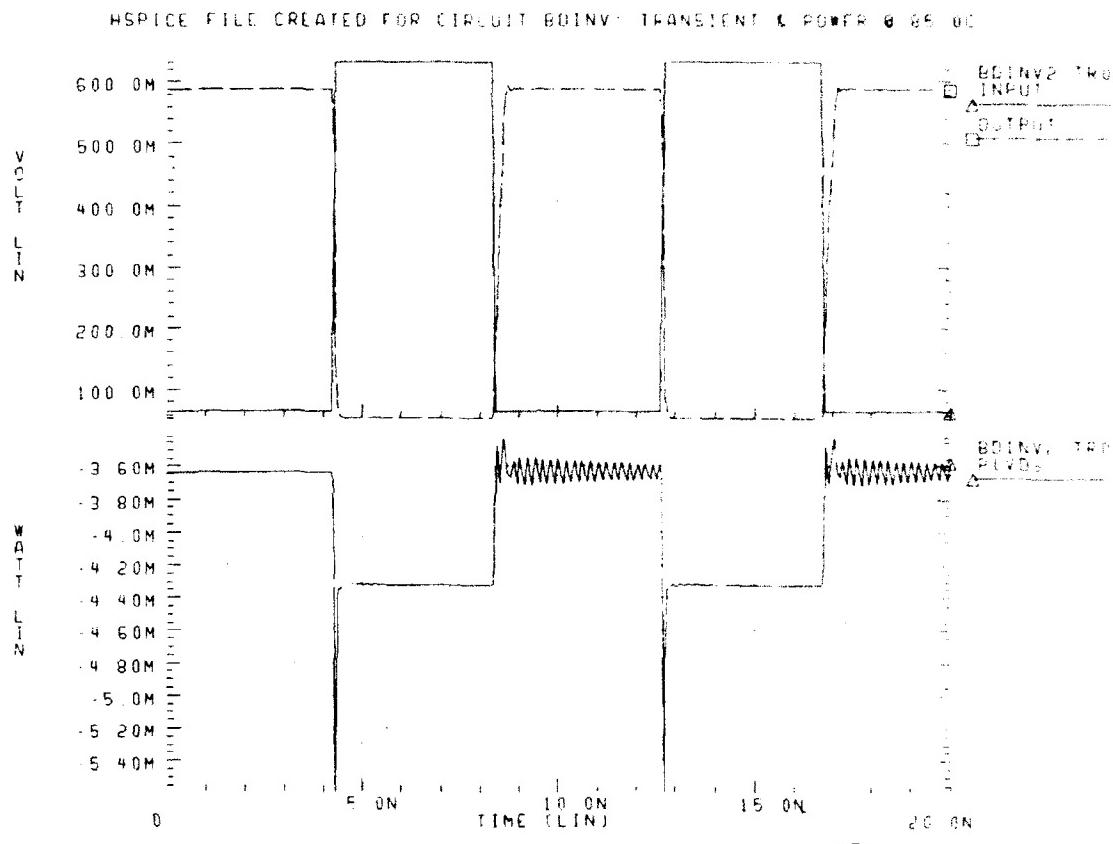


Figure 4.68 BDINV HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the BDINV logic gate operating at a temperature of 25.0C is shown in Figure 4.69 on page 72.

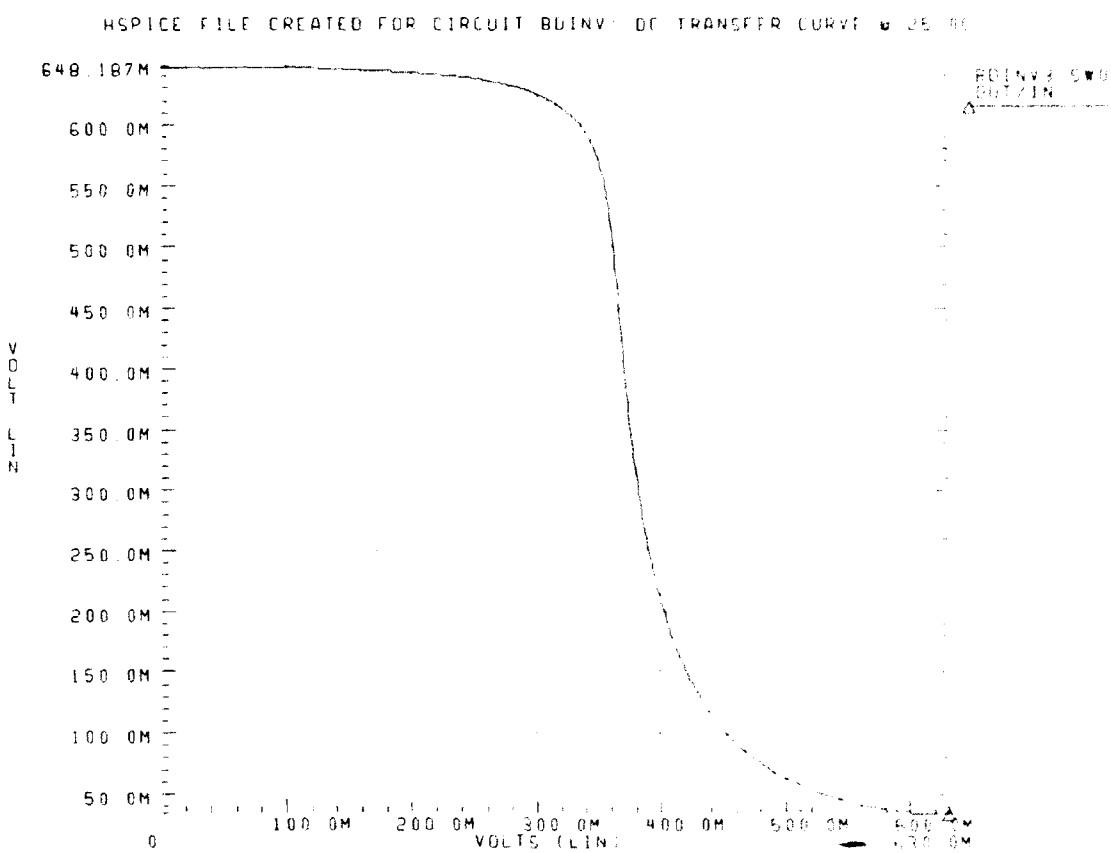


Figure 4.69 BDINV DC Transfer Curve at 25.0C

The DC transfer characteristic of the BDINV logic gate operating at a temperature of 85.0C is shown in Figure 4.70 on page 73.

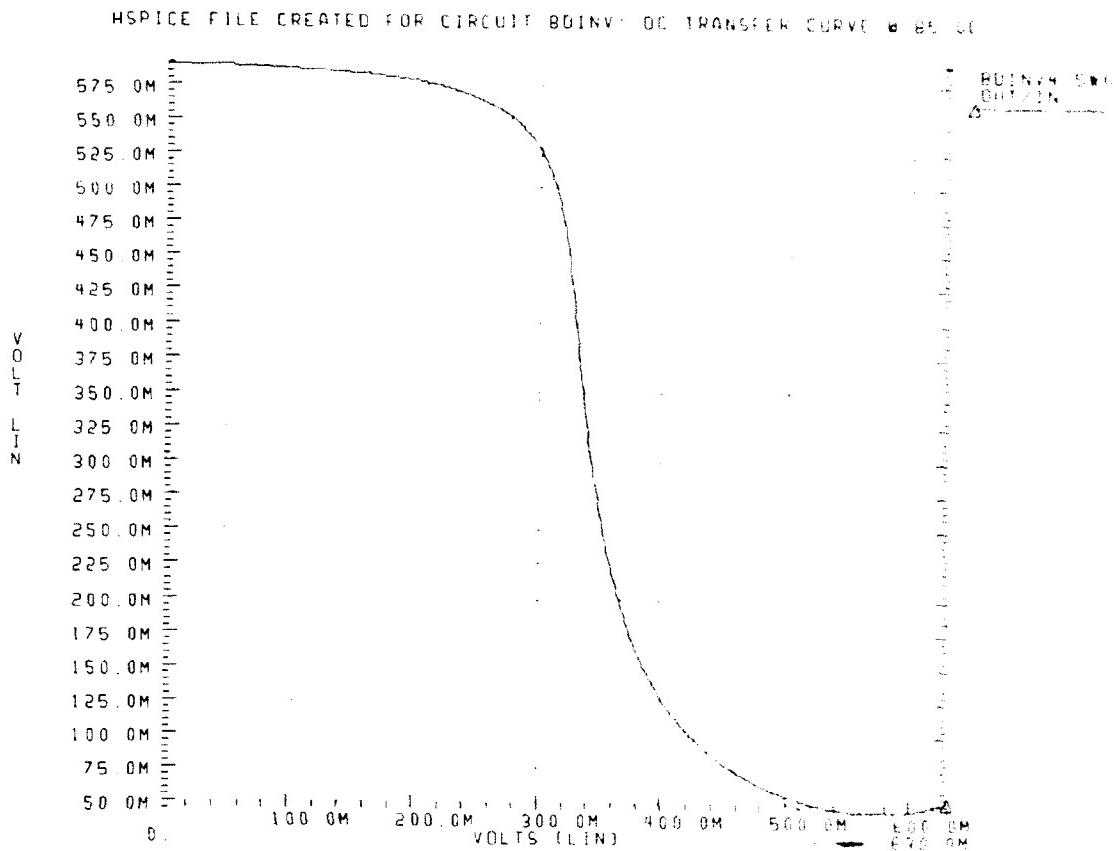


Figure 4.70 BDINV DC Transfer Curve at 85.0C

15. DCFL LATCH (DLATCH)

A data latch is constructed from DCFL logic gates. The DLATCH circuit schematic and logical equivalence are shown in Figure 4.71 on page 73.

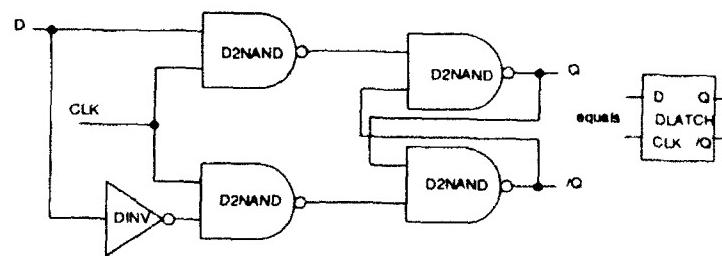


Figure 4.71 DLATCH Schematic And Logical Equivalence

The transient analysis and power dissipation of the DLATCH operating at a temperature of 25.0C is shown in Figure 4.72 on page 74. See "Listing File for DLATCH Transient Analysis @ 25.0C" of Appendix A on page 279.

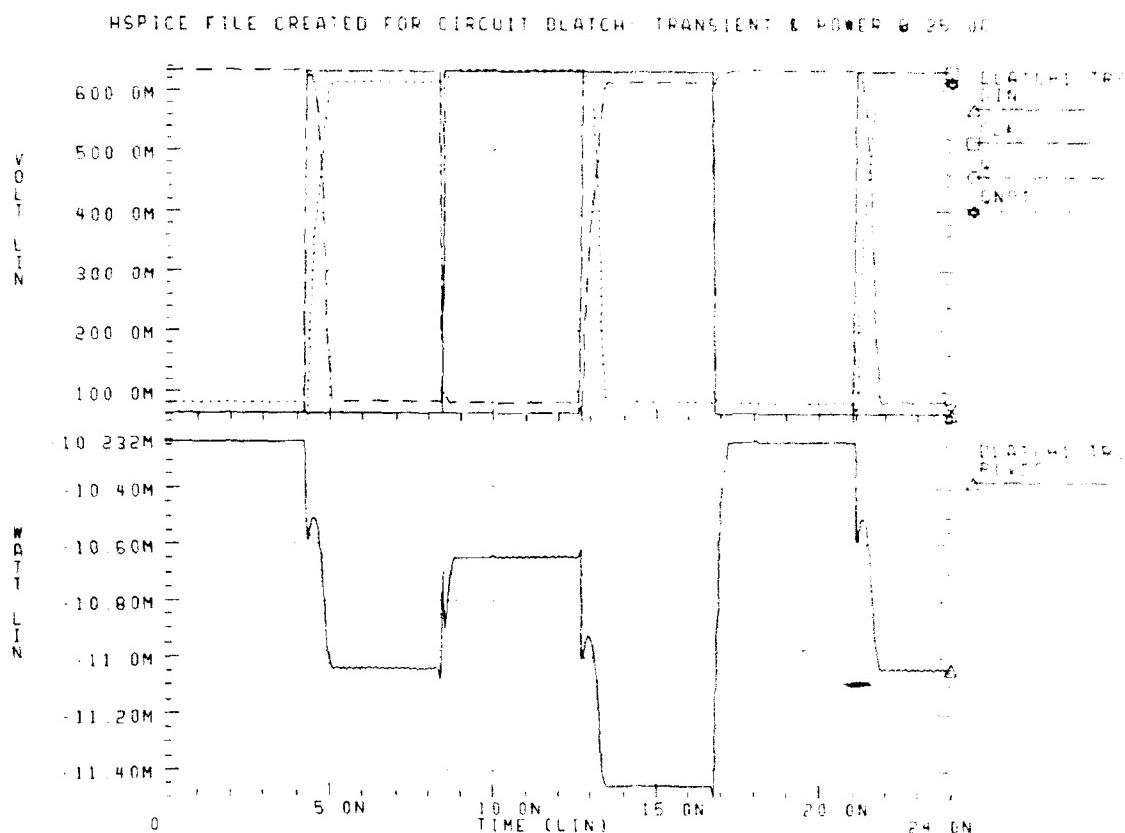


Figure 4.72 DLATCH HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the DLATCH operating at a temperature of 85.0C is shown in Figure 4.73 on page 75.

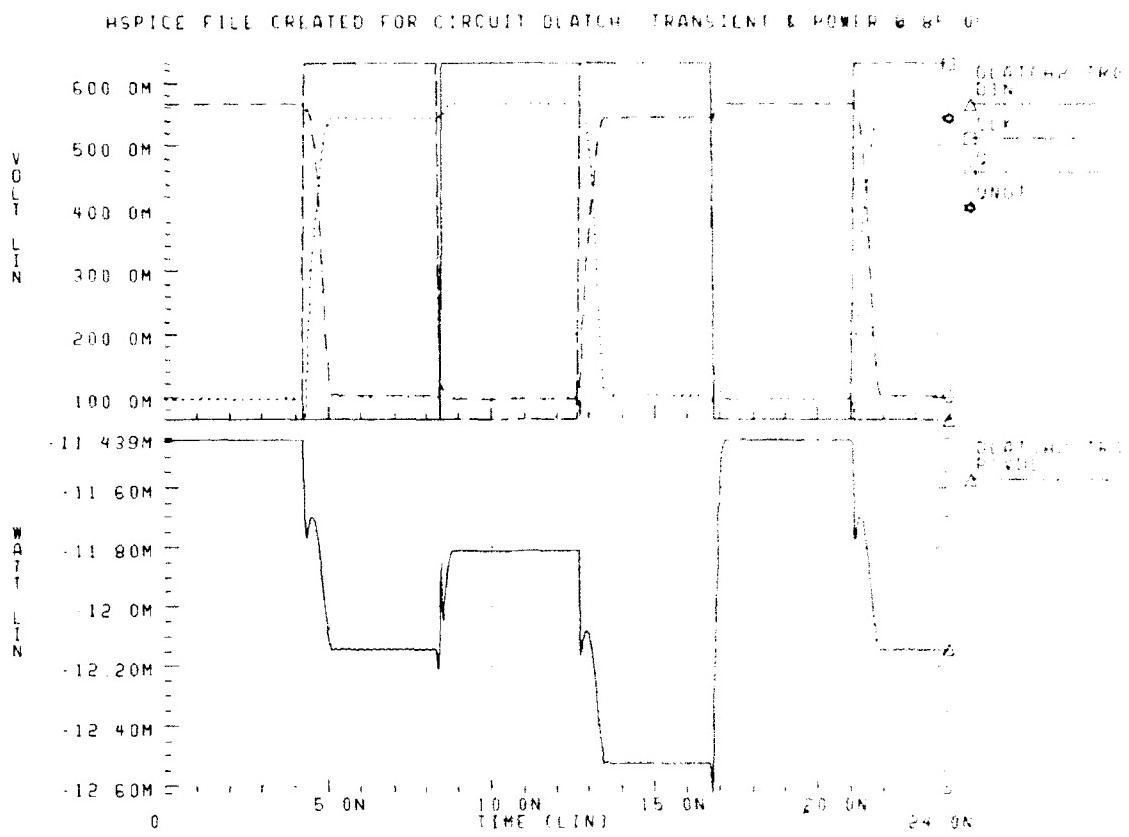


Figure 4.73 DLATCH HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the DLATCH logic gate operating at a temperature of 25.0C is shown in Figure 4.74 on page 76.

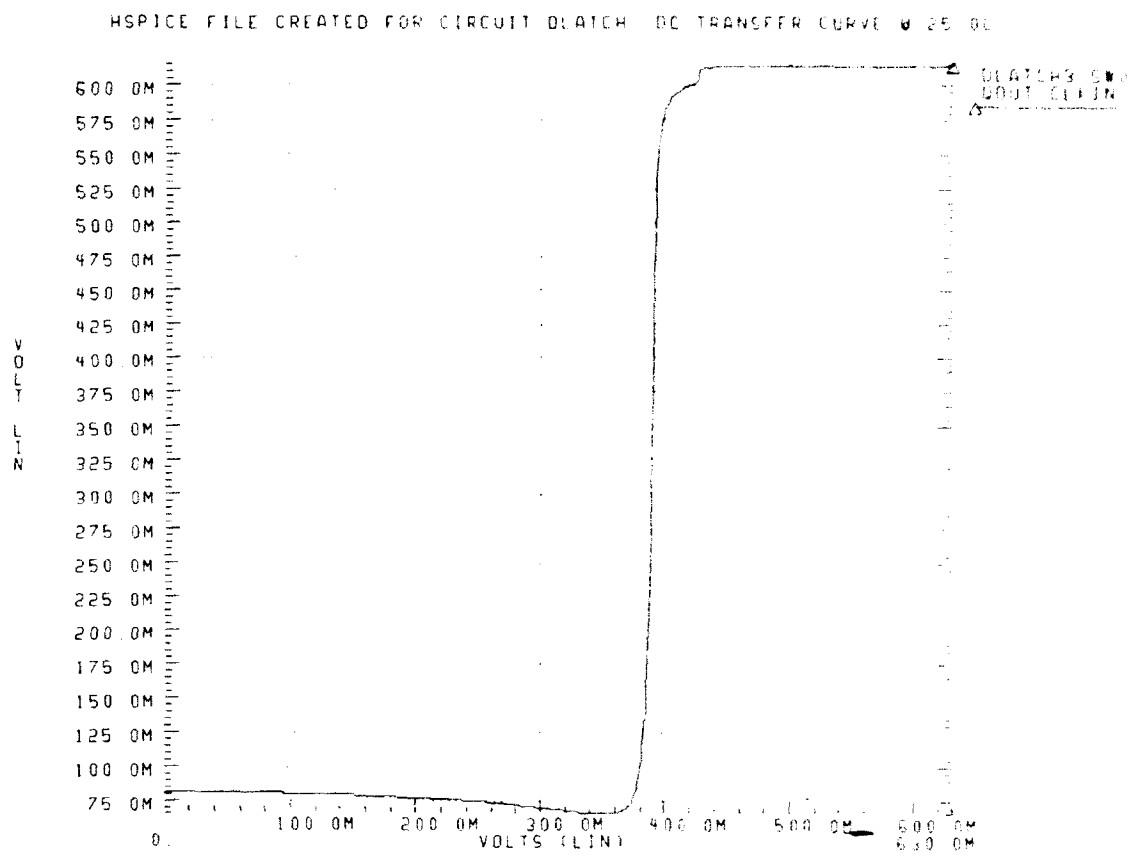


Figure 4.74 DLATCH DC Transfer Curve at 25.0C

The DC transfer characteristic of the DLATCH logic gate operating at a temperature of 85.0C is shown in Figure 4.75 on page 77.

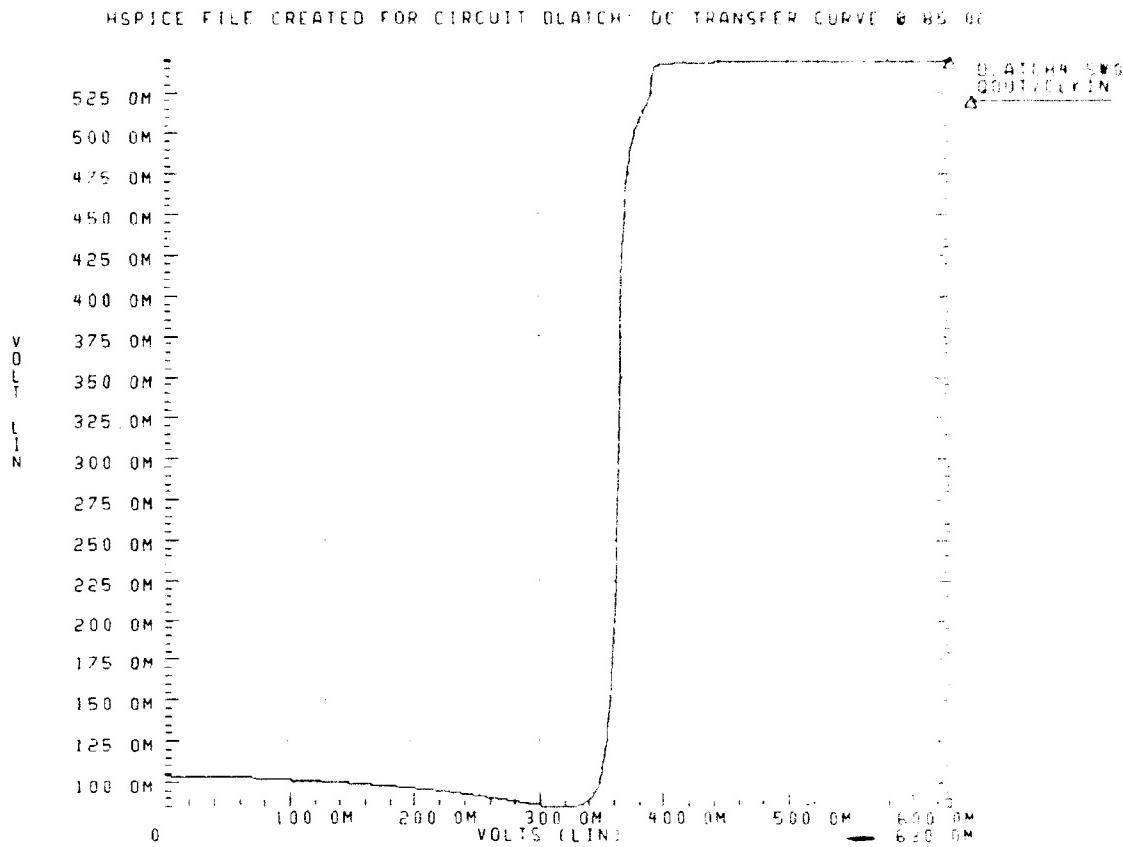


Figure 4.75 DLATCH DC Transfer Curve at 85.0C

16. DCFL /Clear Data Flip-Flop (CPDFF)

A data flip-flop with asynchronous active low CLEAR is constructed from DCFL logic gates. This logic element was constructed specifically for use in the COUNTER circuit. The CPDFF circuit schematic and logical equivalence are shown in Figure 4.76 on page 78.

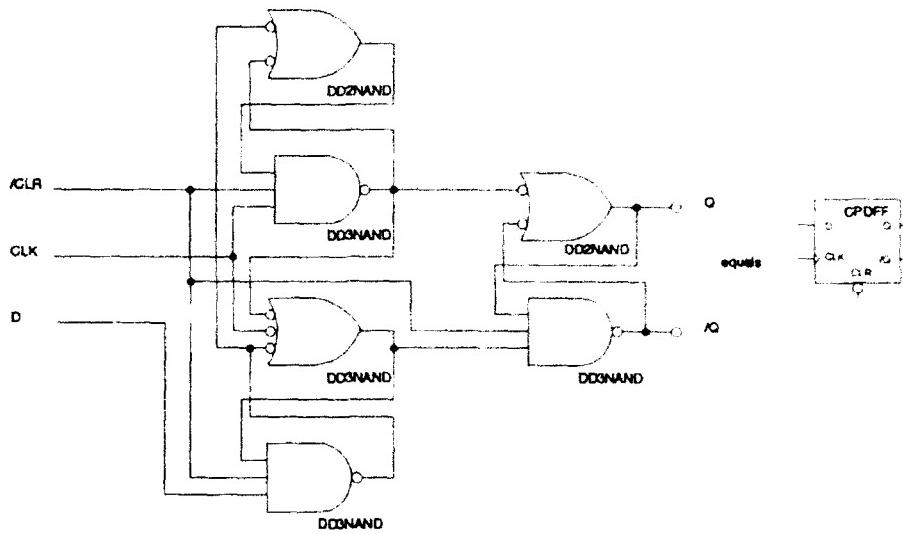


Figure 4.76 CPDFF Schematic And Logical Equivalence

The transient analysis and power dissipation of the CPDFF operating at a temperature of 25.0C is shown in Figure 4.77 on page 79. See "Listing File for CPDFF Transient Analysis @ 25.0C" of Appendix A on page 275.

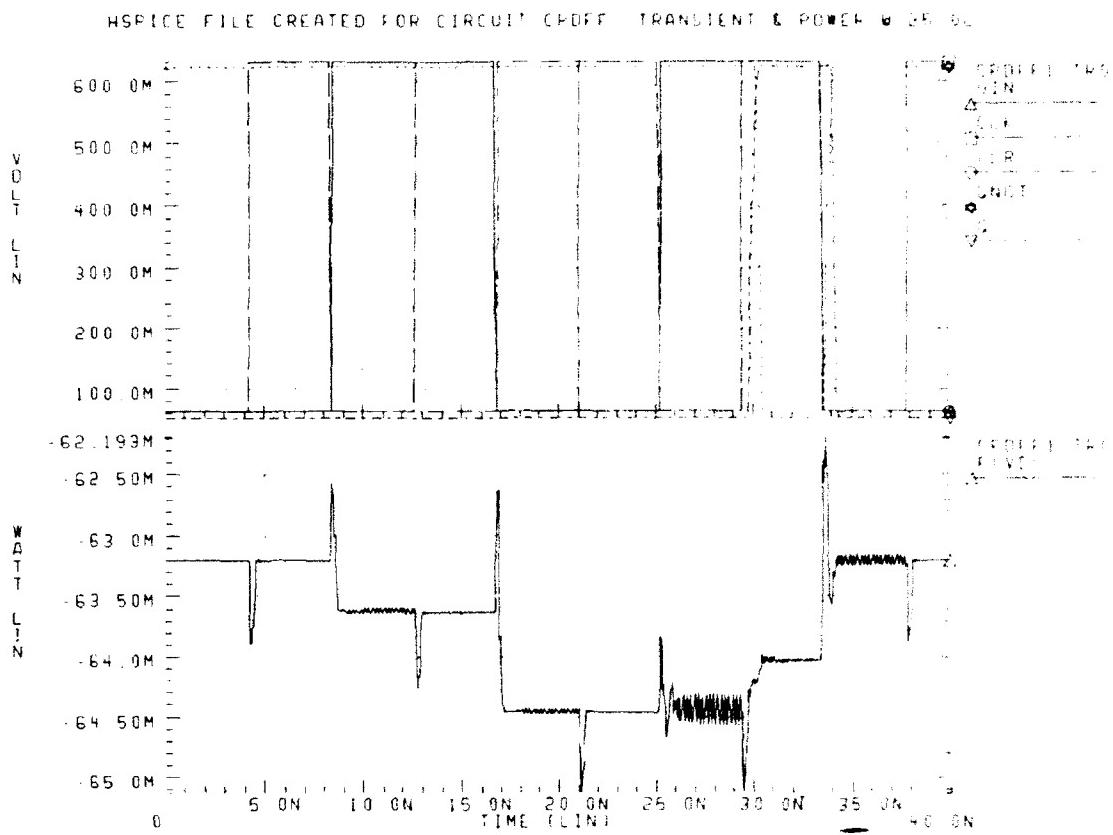


Figure 4.77 CPDFF HSPICE Transient Analysis and Power Dissipation at 25.0°C

The transient analysis and power dissipation of the CPDFF operating at a temperature of 85.0C is shown in Figure 4.78 on page 80.

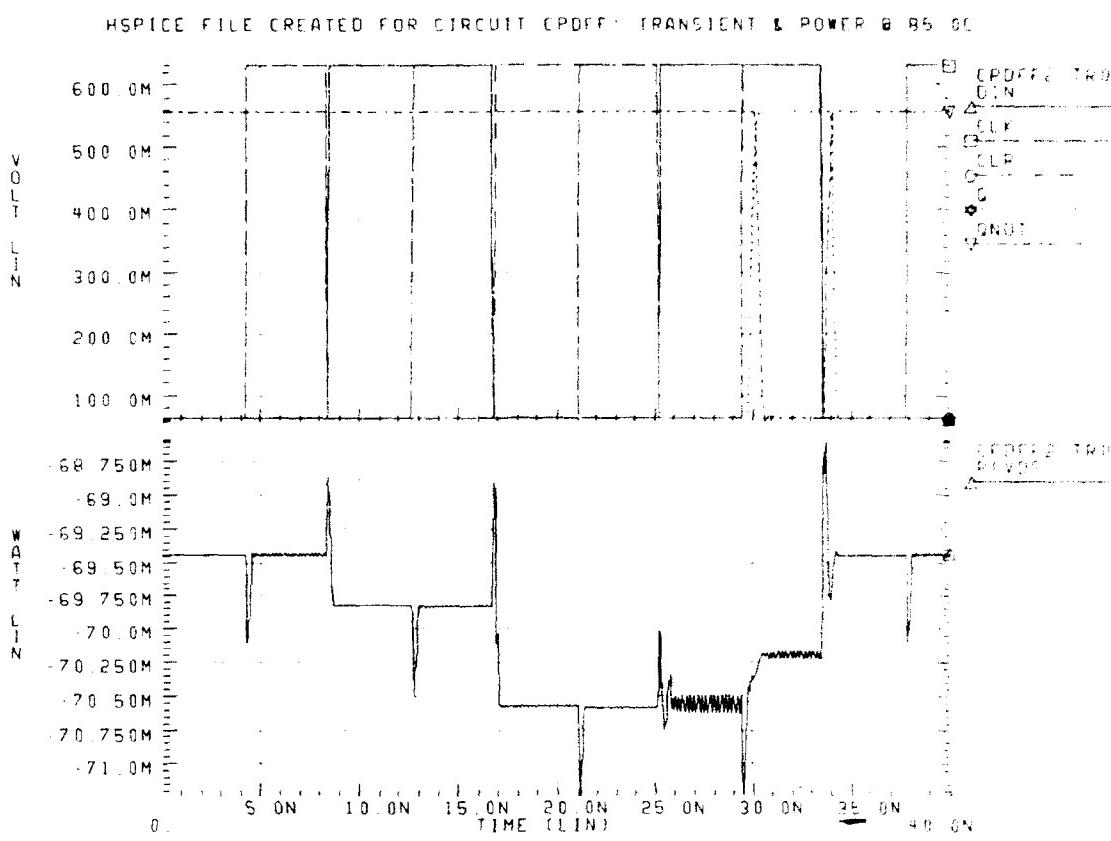


Figure 4.78 CPDFF HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the CPDFF logic gate operating at a temperature of 25.0C is shown in Figure 4.79 on page 81.

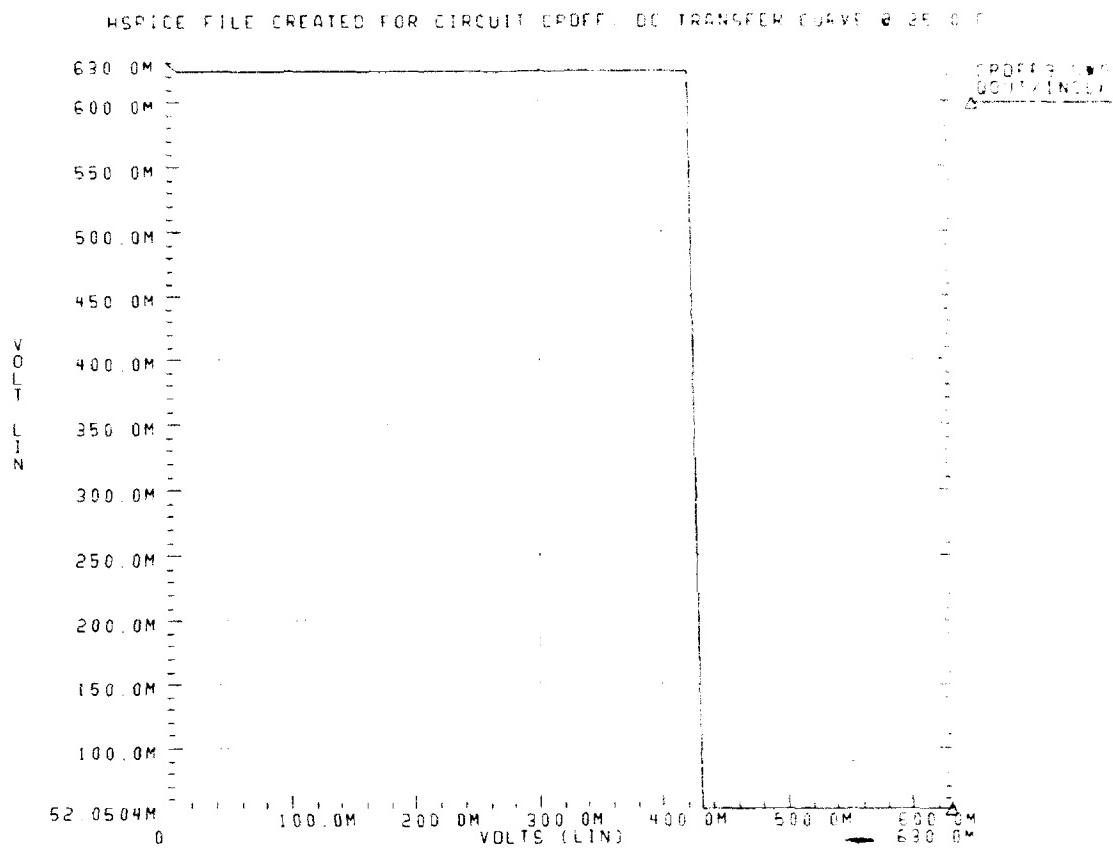


Figure 4.79 CPDFF DC Transfer Curve at 25.0C

The DC transfer characteristic of the CPDFF logic gate operating at a temperature of 85.0C is shown in Figure 4.80 on page 82.

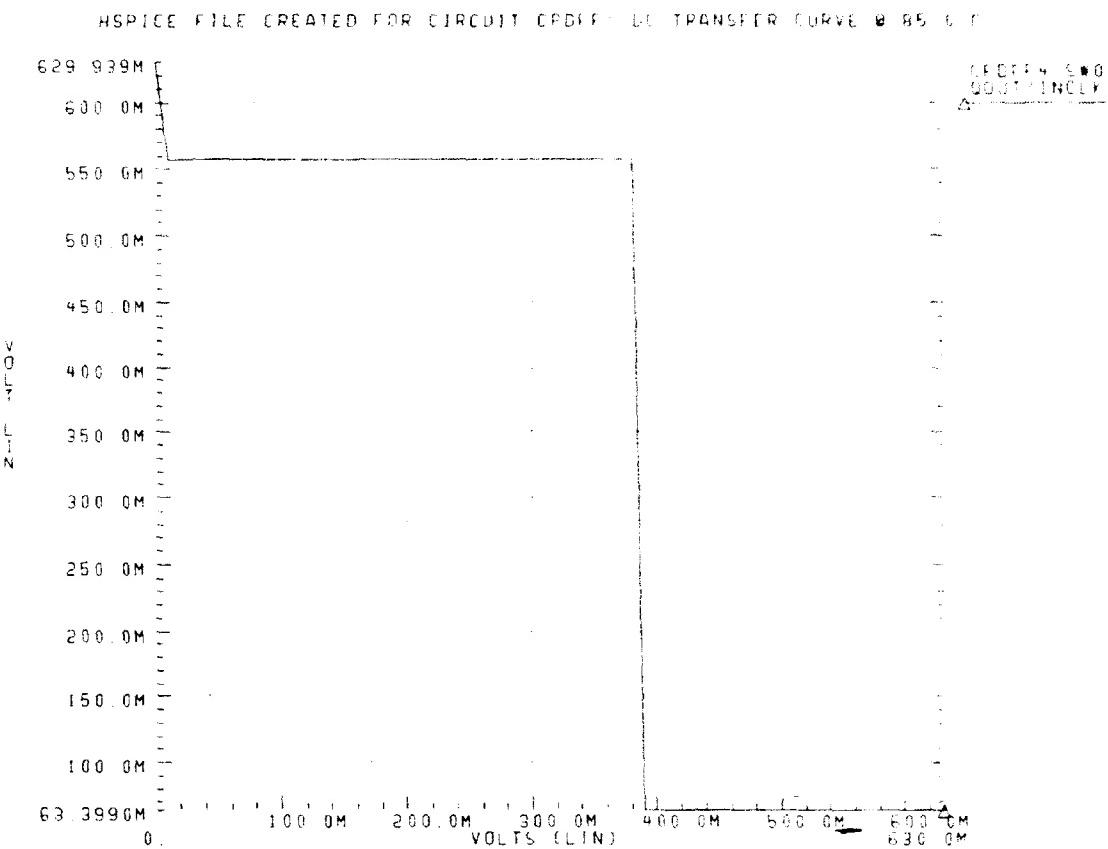


Figure 4.80 CPDFF DC Transfer Curve at 85.0C

B. GaAs DRAM SBFL Logic Circuits

This section will present the specific SBFL gates used, presenting the schematic and logical equivalence for each. The following characteristics for each circuit will be demonstrated and presented: transient analysis under standard load, power consumption at nominal and high temperature, propagation delays and noise margins. These characteristics will be further summarized in TABLE 4.1 on page 158.

1. SBFL Inverter (SINV)

The basic and most widely used SBFL logic element was the inverter, hereafter called "SINV" for SBFL Inverter. As previously mentioned, true NAND gates were infrequently used, the more common SBFL ANDs, NANDs, and ORs were built using NORs with SINVs as per DeMorgan's theorems. See Figure 4.81 on page 83 for the SINV schematic and logical equivalence.

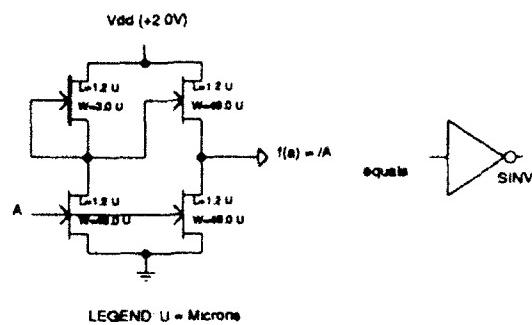


Figure 4.81 Schematic and Logical Equivalence for SINV

The transient analysis and power dissipation of the SINV operating at a temperature of 25.0C is shown in Figure 4.82 on page 83.

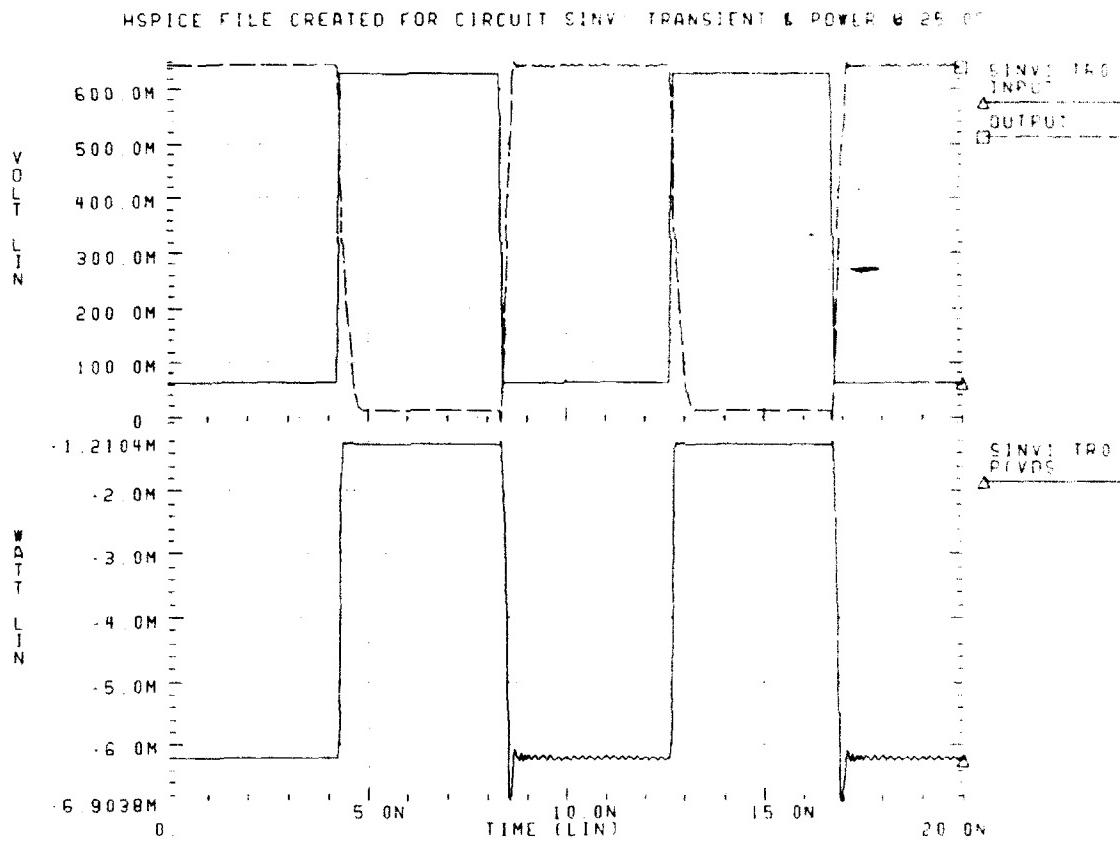


Figure 4.82 SINV HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the SINV operating at a temperature of 85.0C is shown in Figure 4.83 on page 84.

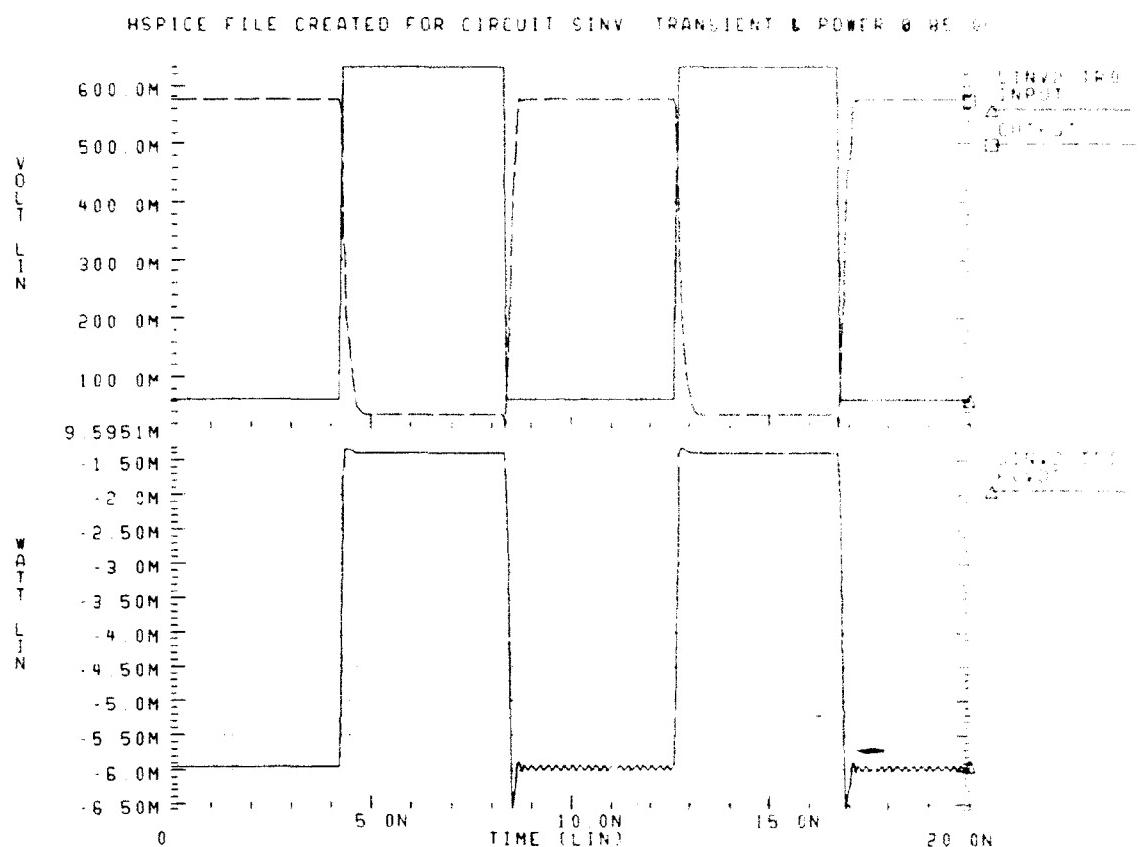


Figure 4.83 SINV HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the SINV logic gate operating at a temperature of 25.0C is shown in Figure 4.84 on page 85.

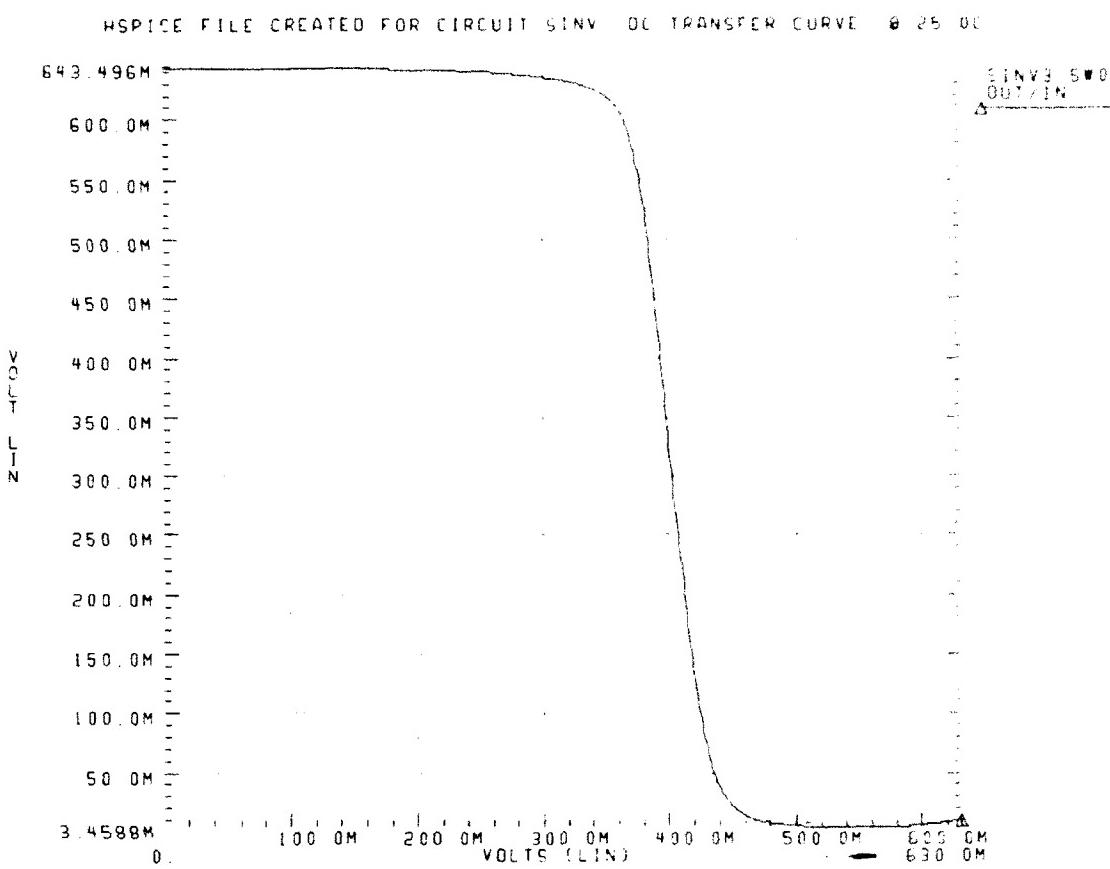


Figure 4.84 SINV DC Transfer Curve at 25.0C

The DC transfer characteristic of the SINV logic gate operating at a temperature of 85.0C is shown in Figure 4.85 on page 86.

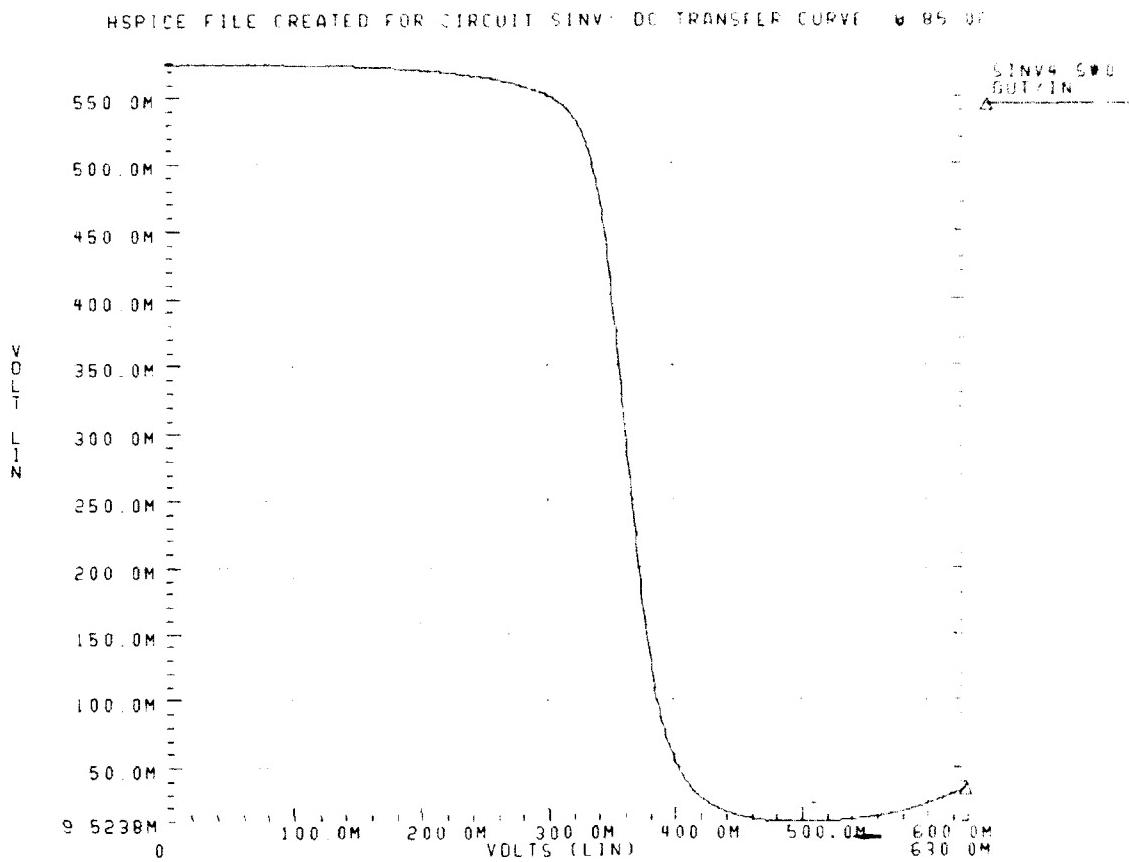


Figure 4.85 SINV DC Transfer Curve at 85.0C

2. Super SBFL Inverter (SSINV)

It was necessary to construct a very fast and powerful driver-inverter for use in the CLOCK circuit. Two reasons were the need to drive many gates and the need to minimize clock skew under heavy load. This SBFL logic element was the super SBFL inverter, hereafter called "SSINV". This very fast and powerful logic element extracts its cost in chip real estate. The sizes of the SSINV MESFETs are very large. See Figure 4.86 on page 87 for the SSINV schematic and logical equivalence.

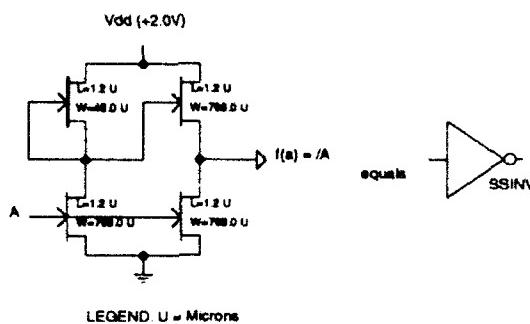


Figure 4.86 Schematic and Logical Equivalence for SSINV

The transient analysis and power dissipation of the SSINV operating at a temperature of 25.0C is shown in Figure 4.87 on page 87.

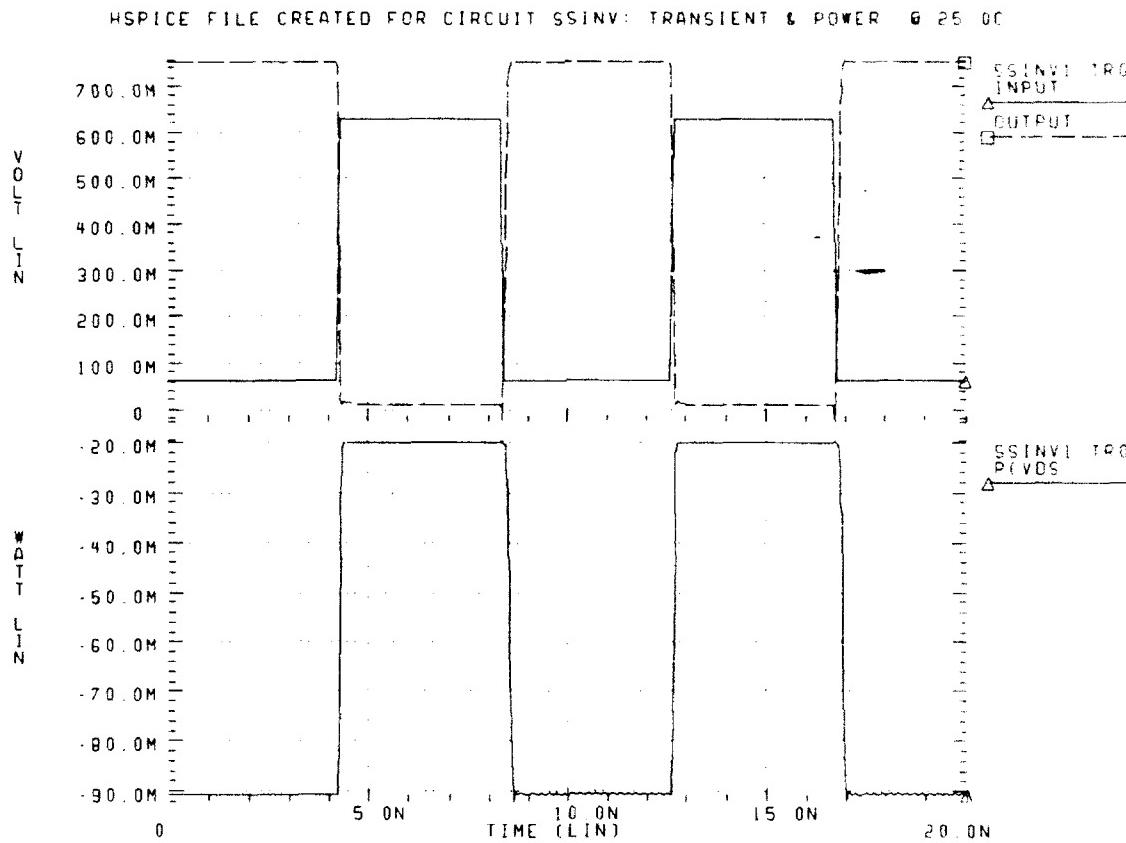


Figure 4.87 SSINV HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the SSINV operating at a temperature of 85.0C is shown in Figure 4.88 on page 88.

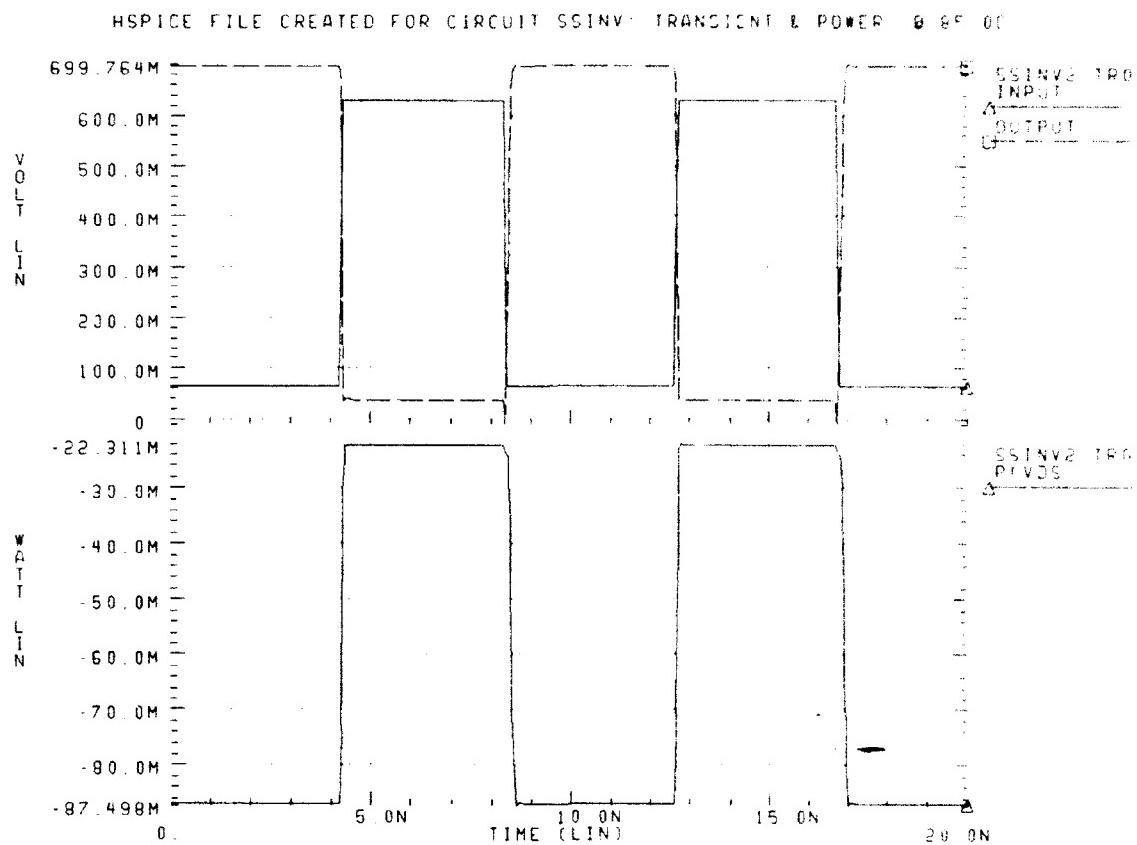


Figure 4.88 SSINV HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the SSINV logic gate operating at a temperature of 25.0C is shown in Figure 4.89 on page 89.

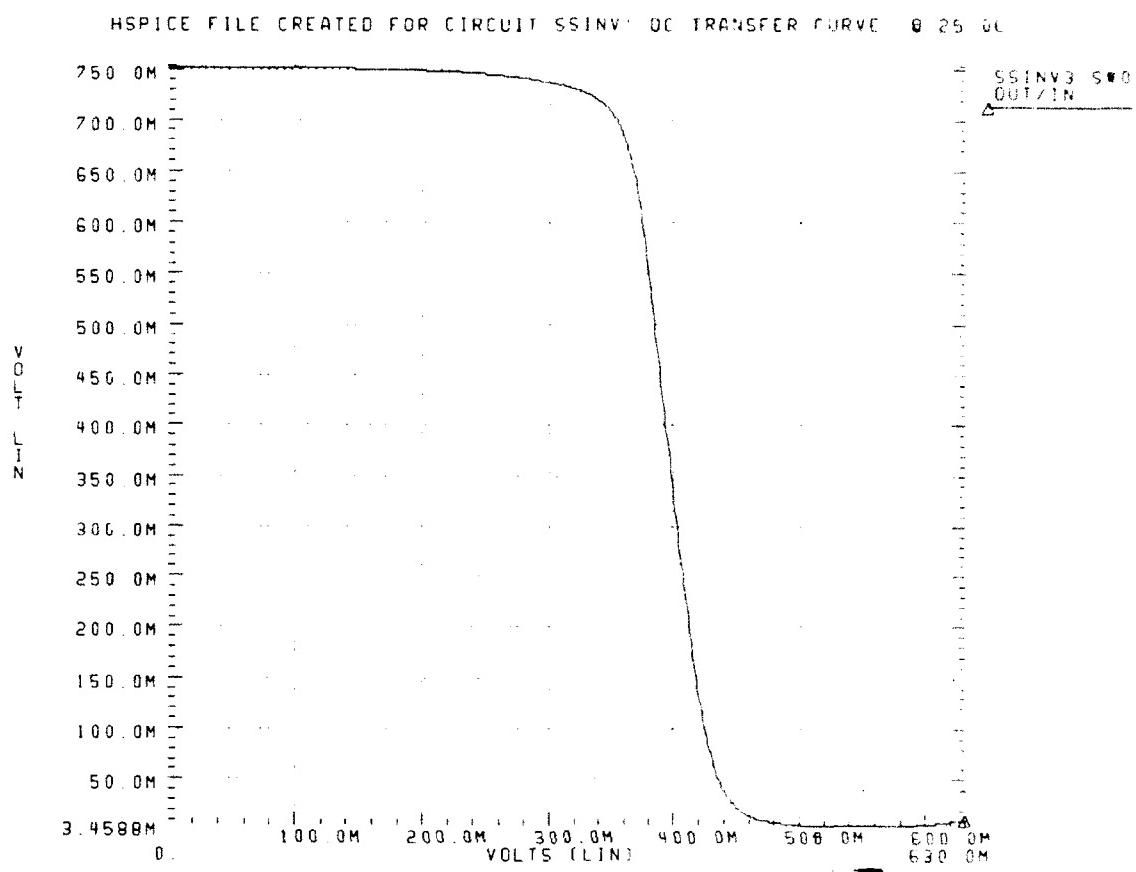


Figure 4.89 SSINV DC Transfer Curve at 25.0C

The DC transfer characteristic of the SSINV logic gate operating at a temperature of 85.0C is shown in Figure 4.85 on page 86.

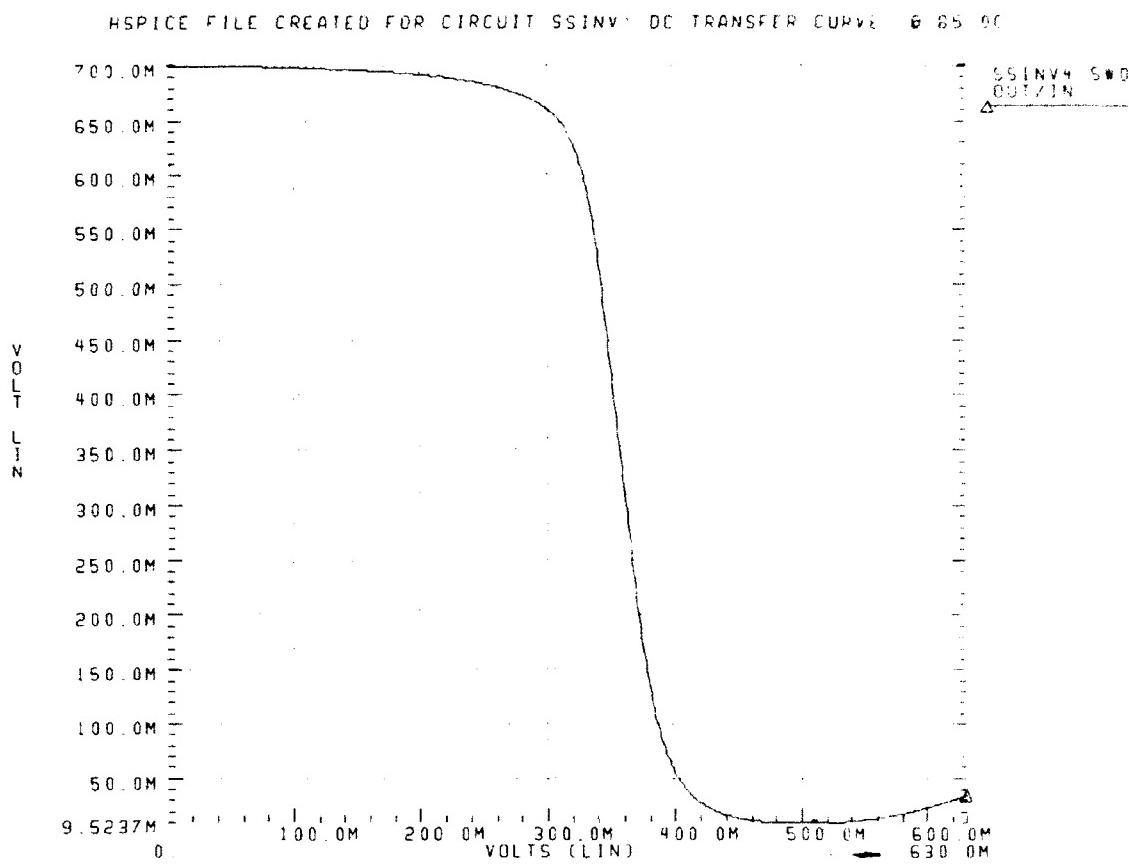


Figure 4.90 SSINV DC Transfer Curve at 85.0C

3. SBFL 2-input NOR Gate (S2NOR)

The following graphs represent the operating characteristics of the S2NOR. As previously mentioned, true NAND gates were infrequently used, the more common SBFL ANDs, NANDs, and ORs were built using NORs with SINVs as per DeMorgan's theorems. See Figure 4.91 on page 91 for the S2NOR schematic and logical equivalence.

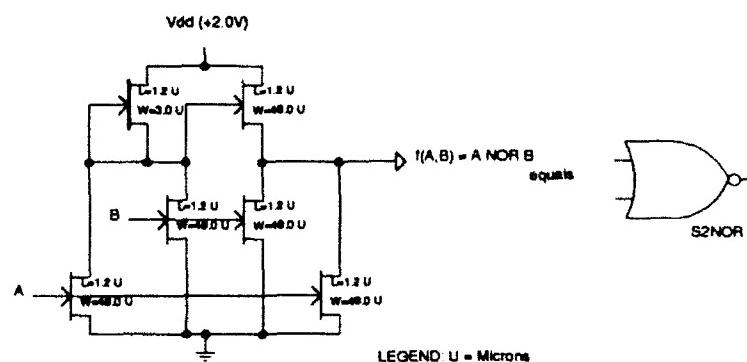


Figure 4.91 Schematic and Logical Equivalence for S2NOR

The transient analysis and power dissipation of the S2NOR operating at a temperature of 25.0C is shown in Figure 4.92 on page 91.

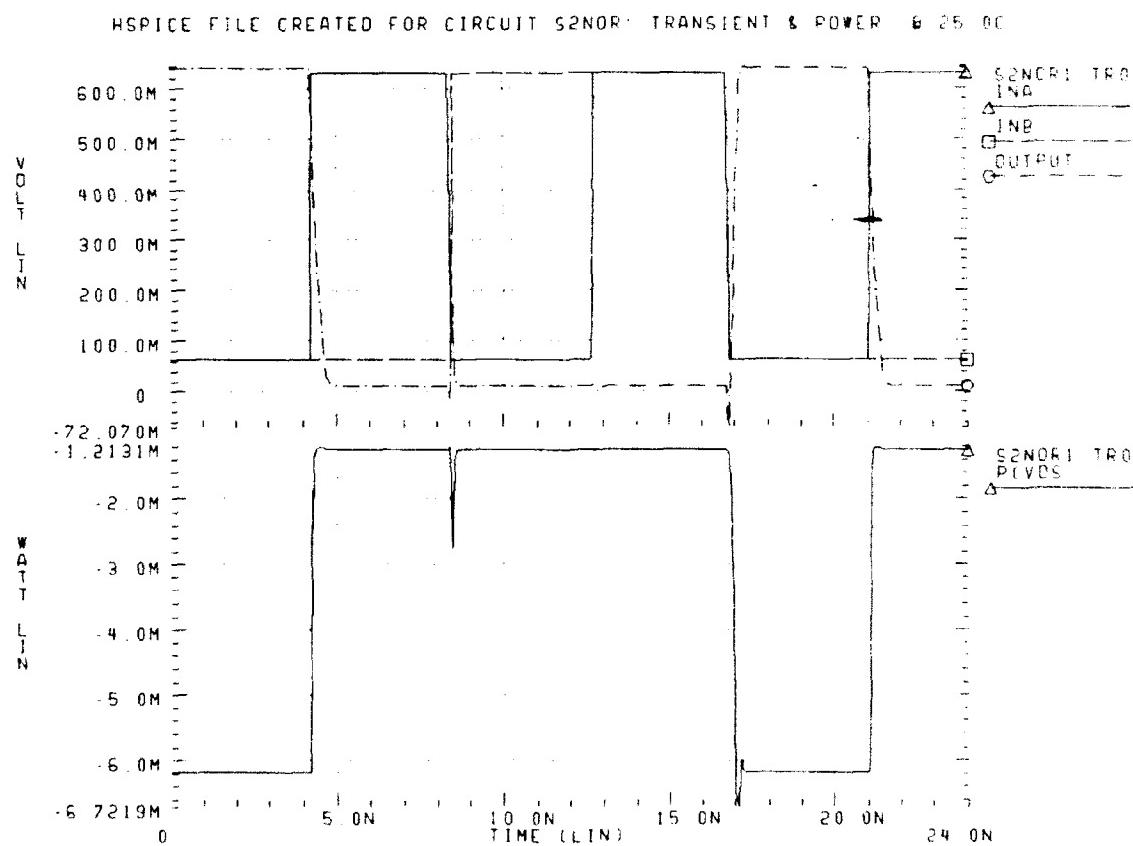


Figure 4.92 S2NOR HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the S2NOR operating at a temperature of 85.0C is shown in Figure 4.93 on page 92.

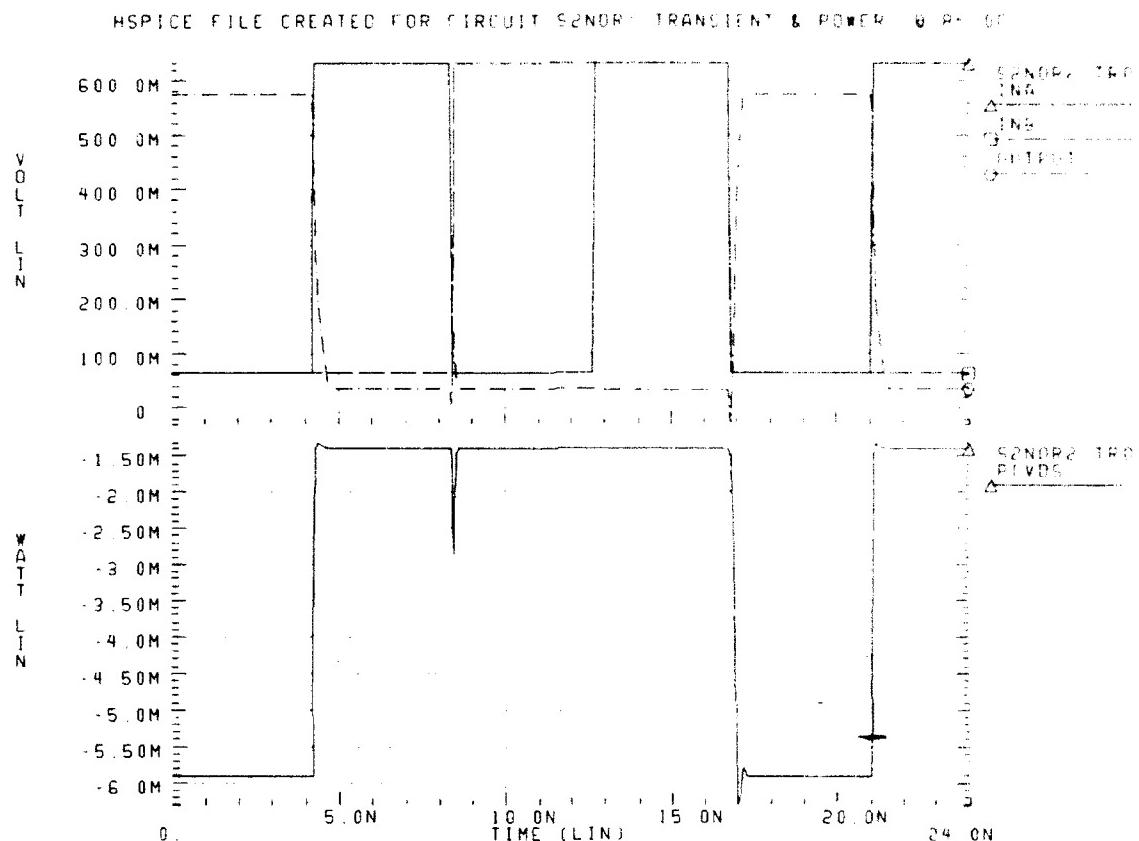


Figure 4.93 S2NOR HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the S2NOR logic gate operating at a temperature of 25.0C is shown in Figure 4.94 on page 93.

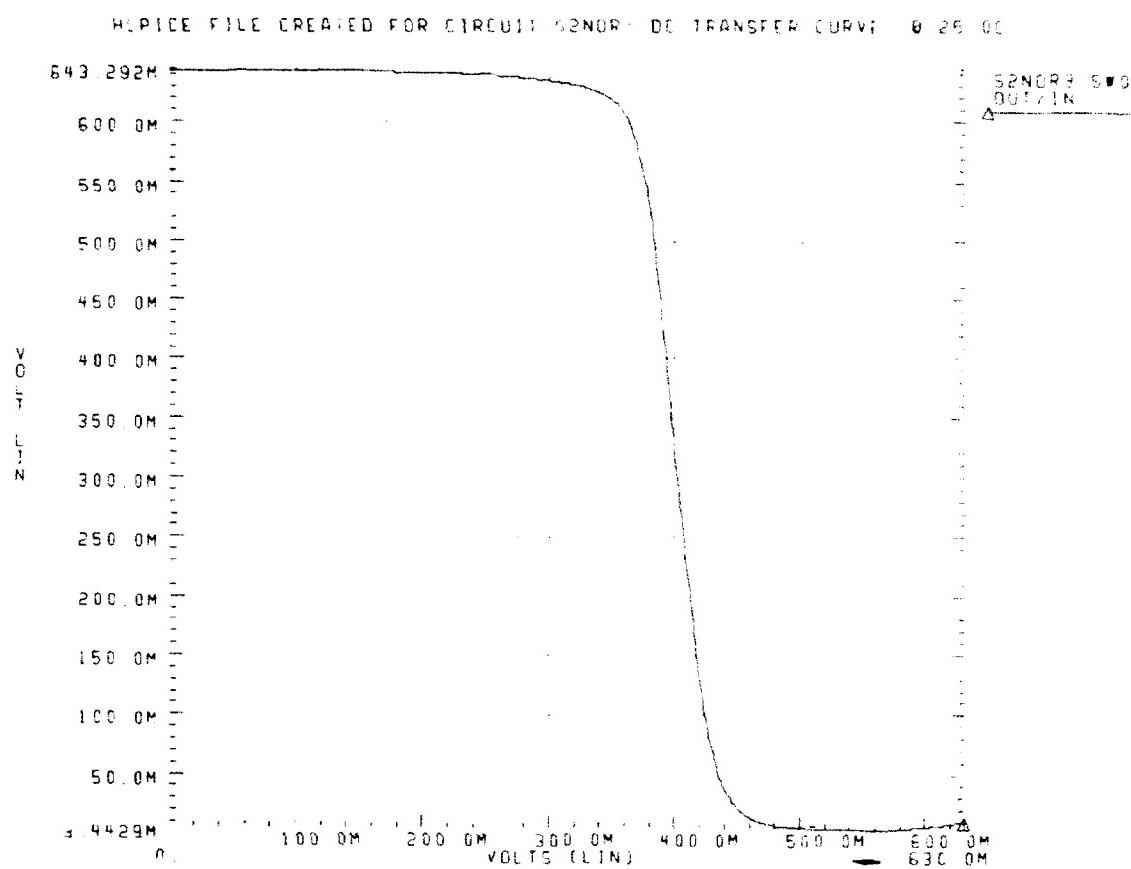


Figure 4.94 S2NOR DC Transfer Curve at 25.0C

The DC transfer characteristic of the S2NOR logic gate operating at a temperature of 85.0C is shown in Figure 4.95 on page 94.

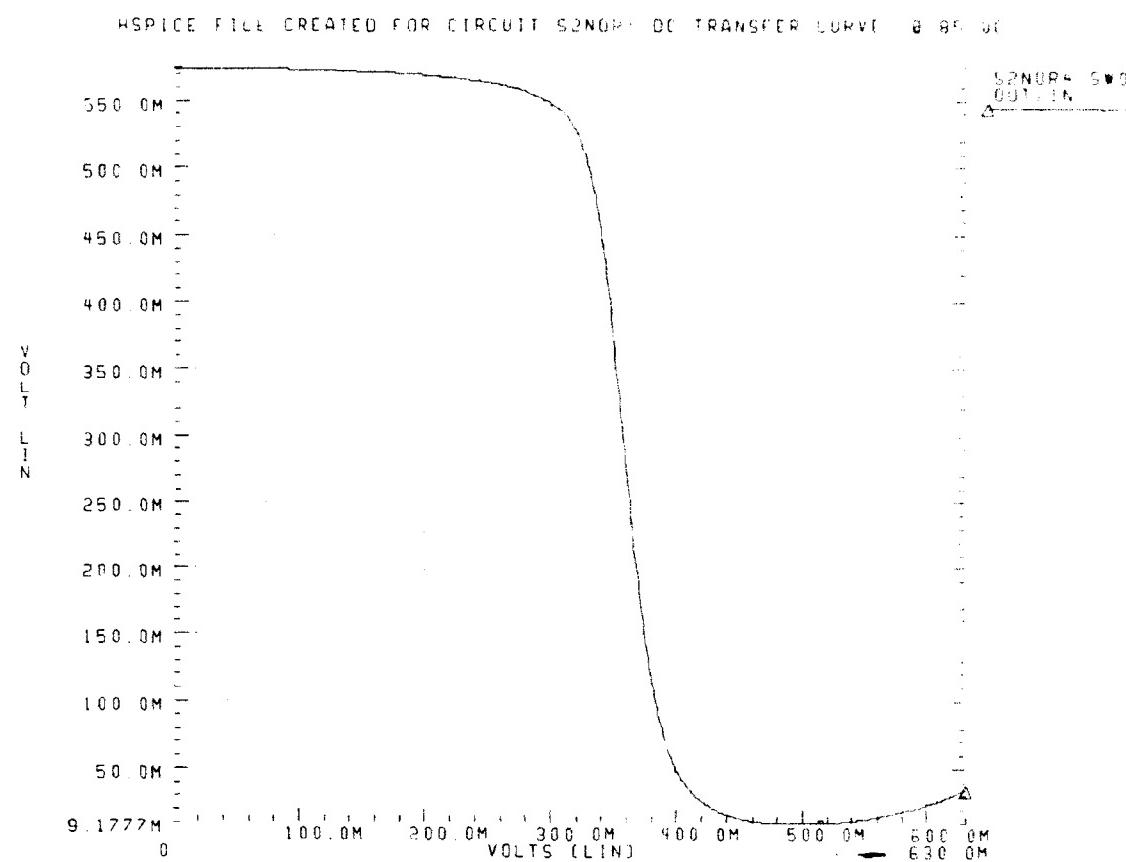


Figure 4.95 S2NOR DC Transfer Curve at 85.0C

4. SBFL 3-input NOR Gate (S3NOR)

The following graphs represent the operating characteristics of the S3NOR. See Figure 4.96 on page 95 for the S3NOR schematic and logical equivalence.

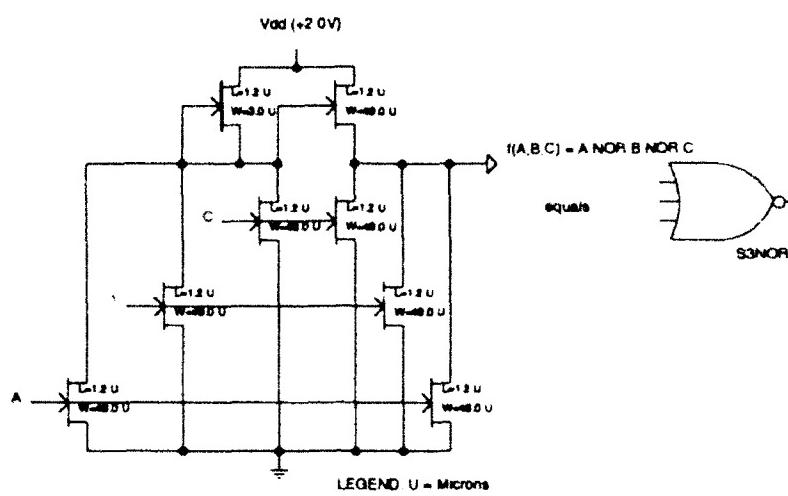


Figure 4.96 Schematic and Logical Equivalence for S3NOR

The transient analysis and power dissipation of the S3NOR operating at a temperature of 25.0C is shown in Figure 4.97 on page 96.

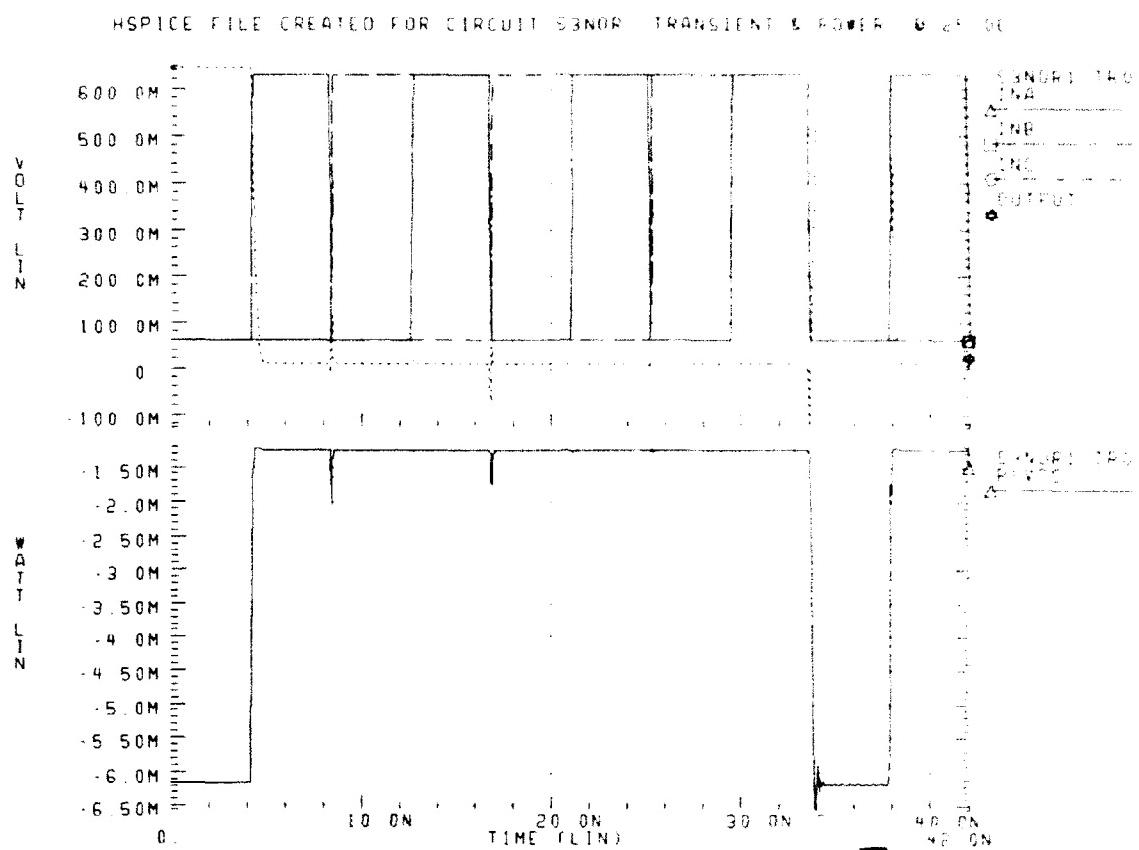


Figure 4.97 S3NOR HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the S3NOR operating at a temperature of 85.0C is shown in Figure 4.98 on page 97.

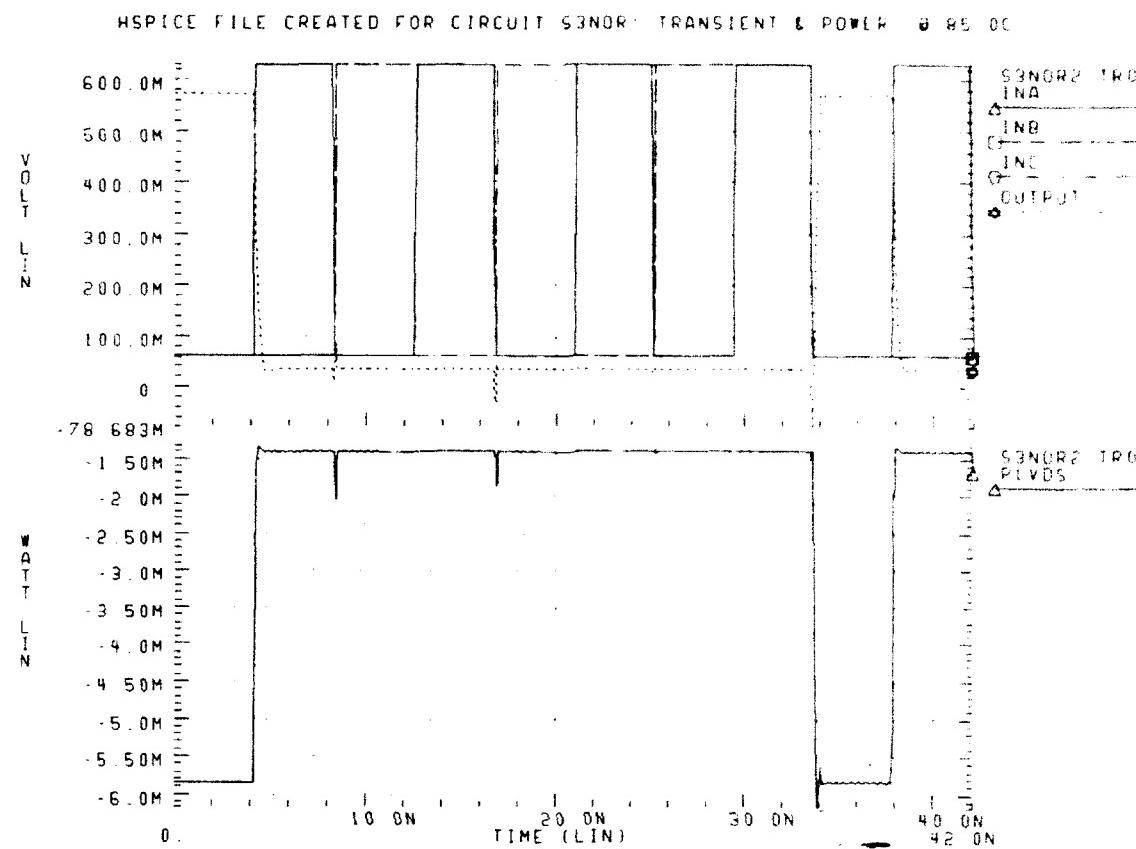


Figure 4.98 S3NOR HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the S3NOR logic gate operating at a temperature of 25.0C is shown in Figure 4.99 on page 98.

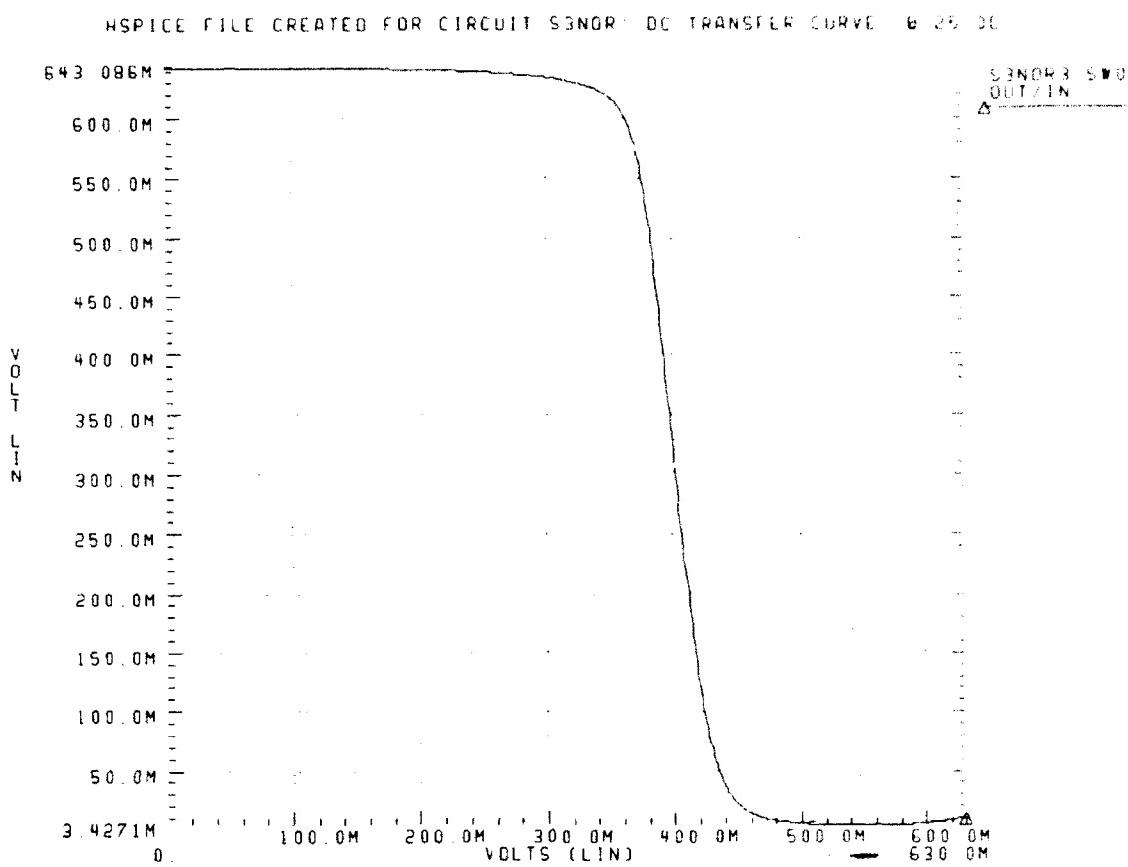


Figure 4.99 S3NOR DC Transfer Curve at 25.0C

The DC transfer characteristic of the S3NOR logic gate operating at a temperature of 85.0C is shown in Figure 4.100 on page 99.

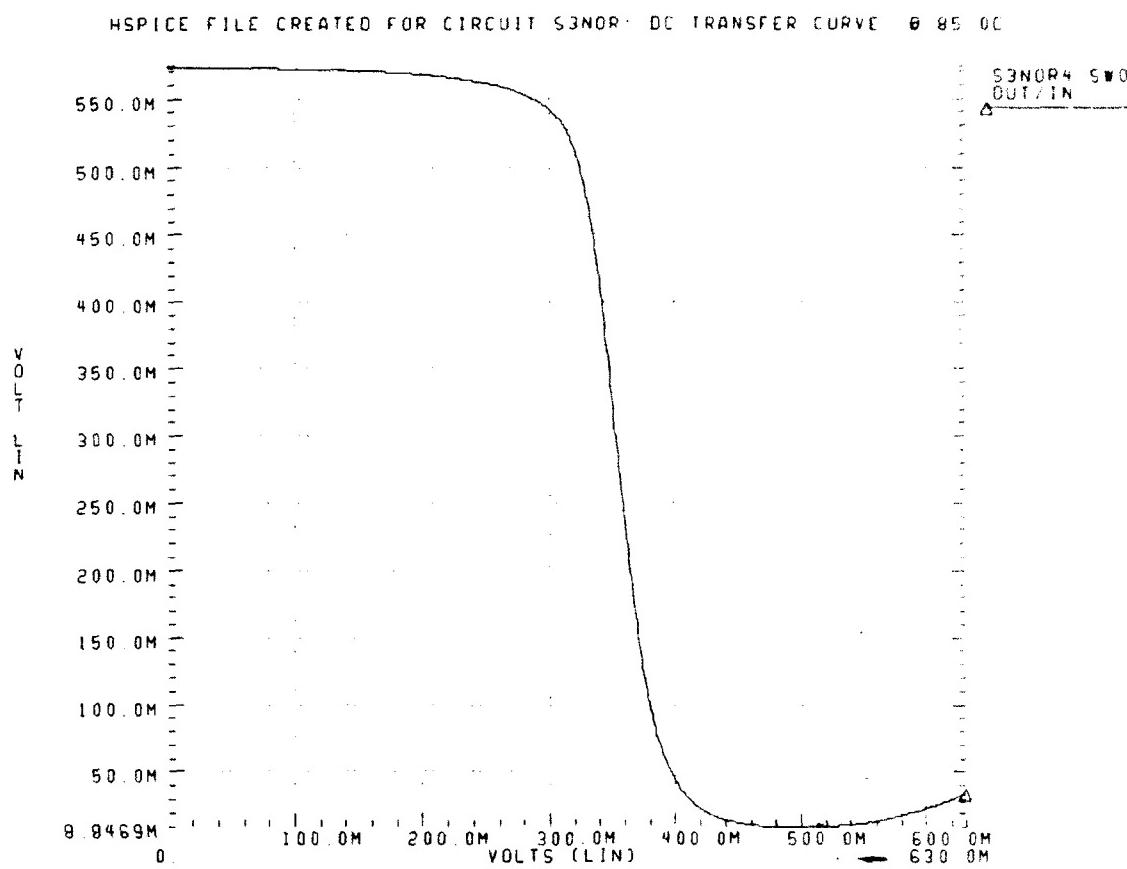


Figure 4.100 S3NOR DC Transfer Curve at 85.0C

5. SBFL 4-input NOR Gate (S4NOR)

The following graphs represent the operating characteristics of the S4NOR. As previously mentioned, true NAND gates were infrequently used, the more common SBFL ANDs, NANDs, and ORs were built using NORs with SINVs as per DeMorgan's theorems. See Figure 4.101 on page 100 for the S4NOR schematic and logical equivalence.

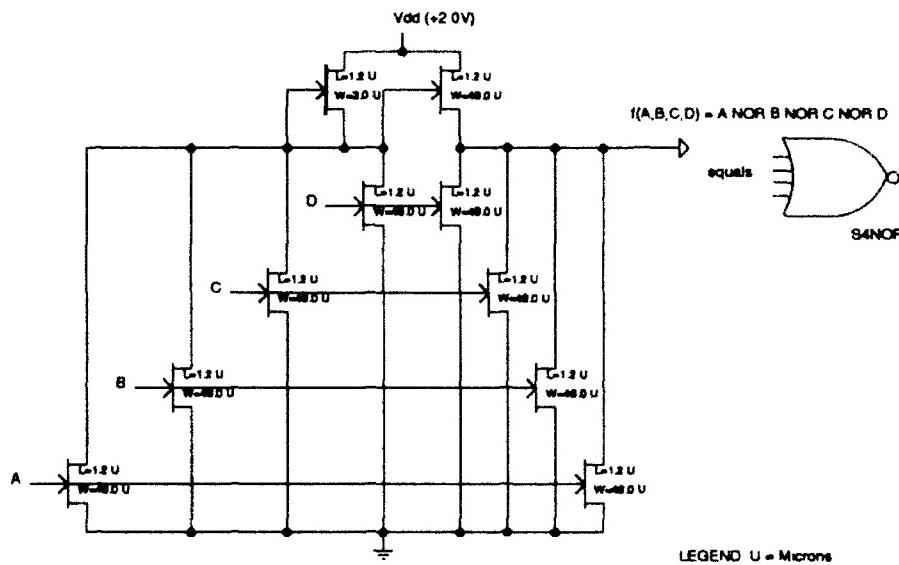


Figure 4.101 Schematic and Logical Equivalence for S4NOR

The transient analysis and power dissipation of the S4NOR operating at a temperature of 25.0°C is shown in Figure 4.102 on page 101.

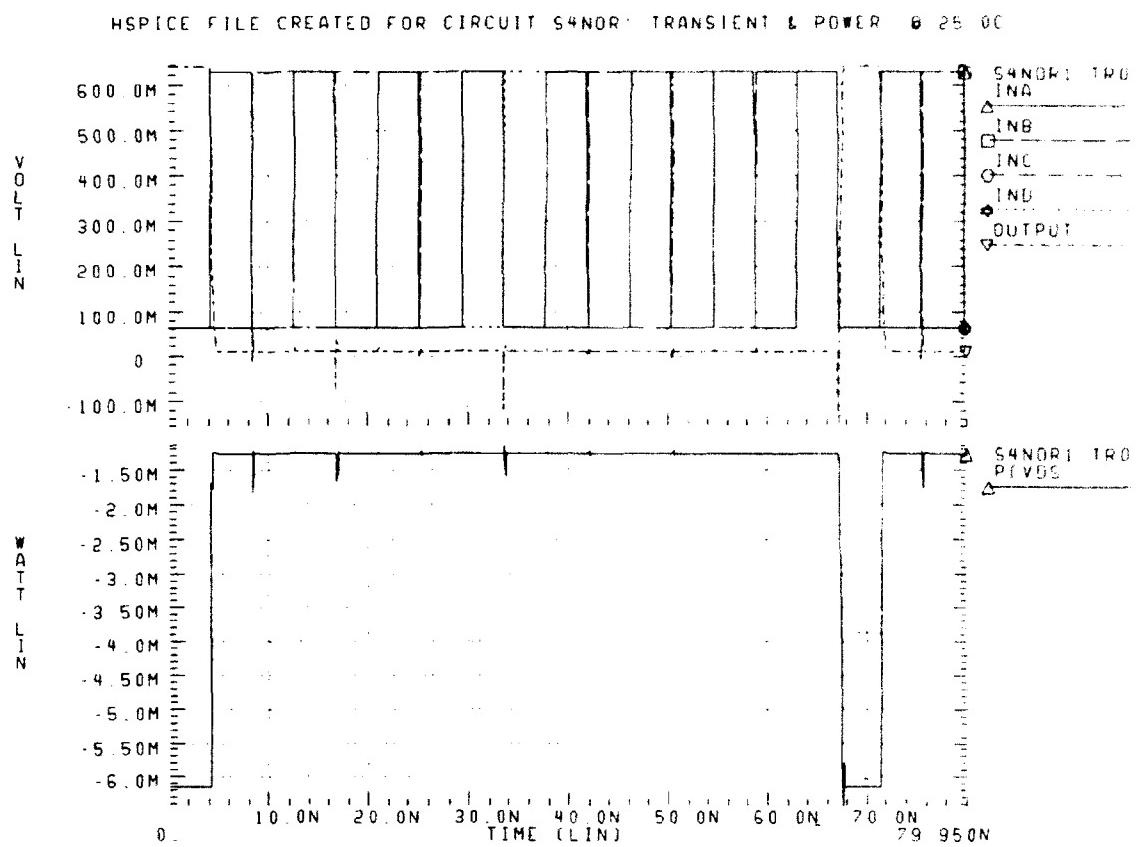


Figure 4.102 S4NOR HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the S4NOR operating at a temperature of 85.0C is shown in Figure 4.103 on page 102.

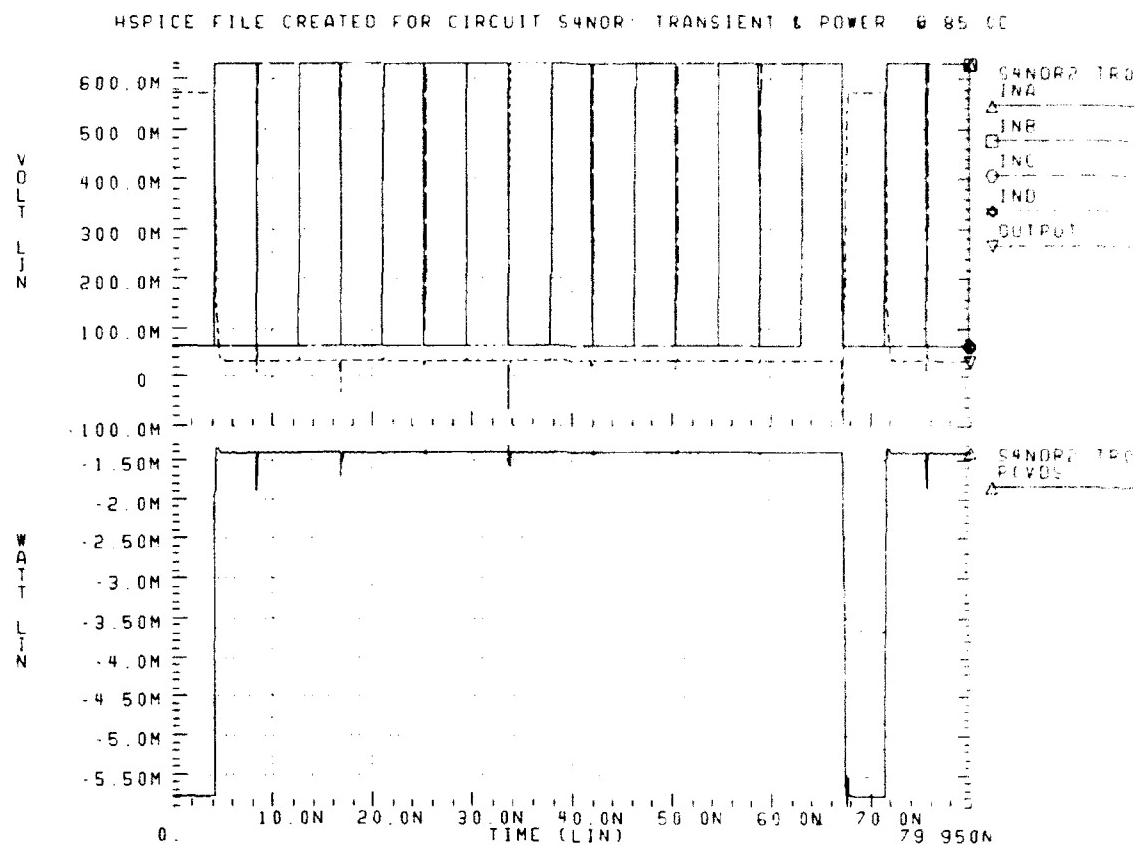


Figure 4.103 S4NOR HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the S4NOR logic gate operating at a temperature of 25.0C is shown in Figure 4.104 on page 103.

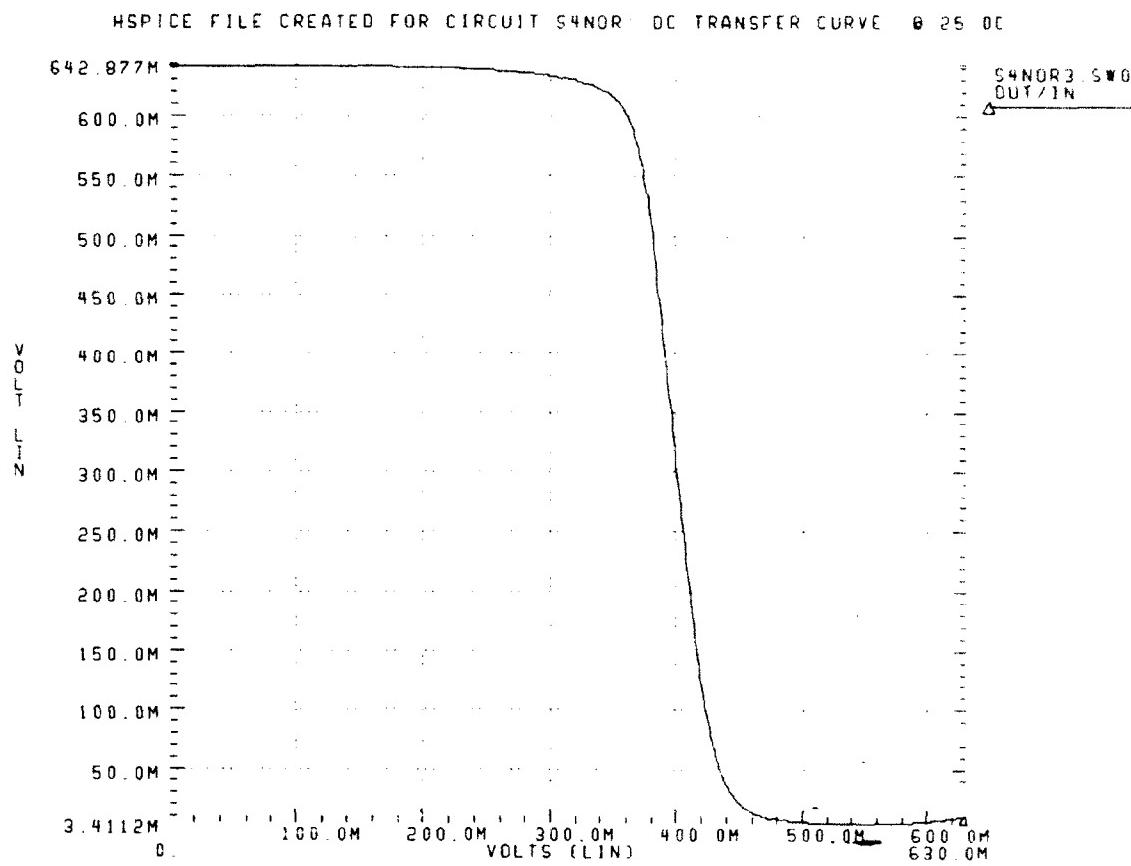


Figure 4.104 S4NOR DC Transfer Curve at 25.0C

The DC transfer characteristic of the S4NOR logic gate operating at a temperature of 85.0C is shown in Figure 4.105 on page 104.

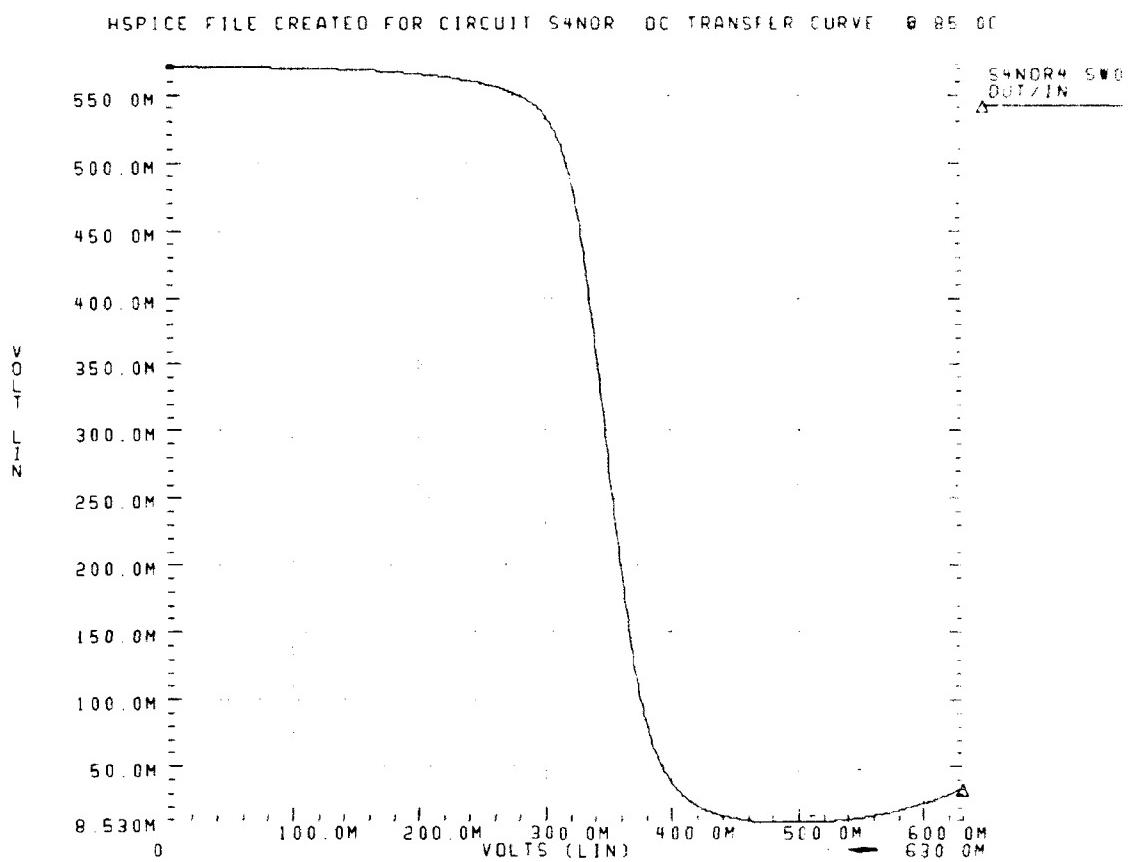


Figure 4.105 S4NOR DC Transfer Curve at 85.0C

6. SBFL 3-input OR Gate (S3OR)

The following graphs represent the operating characteristics of the S3OR. As previously mentioned, true NAND gates were infrequently used, the more common SBFL ANDs, NANDs, and ORs were built using NORs with SINVs as per DeMorgan's theorems. See Figure 4.106 on page 104 for the S3OR schematic and logical equivalence.

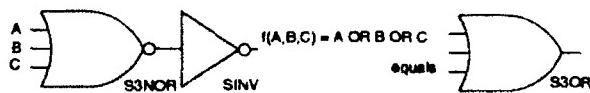


Figure 4.106 Schematic and Logical Equivalence for S3OR

The transient analysis and power dissipation of the S3OR operating at a temperature of 25.0C is shown in Figure 4.107 on page 105.

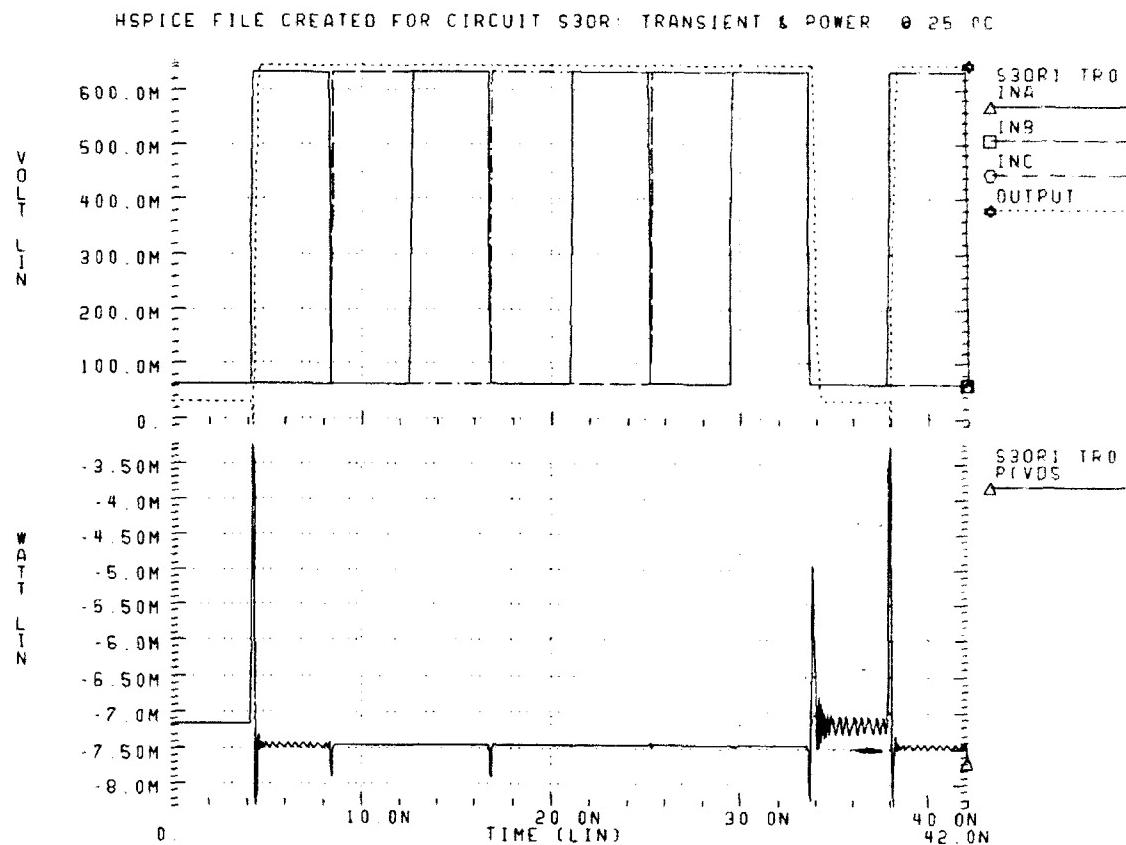


Figure 4.107 S3OR HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the S3OR operating at a temperature of 85.0C is shown in Figure 4.108 on page 106.

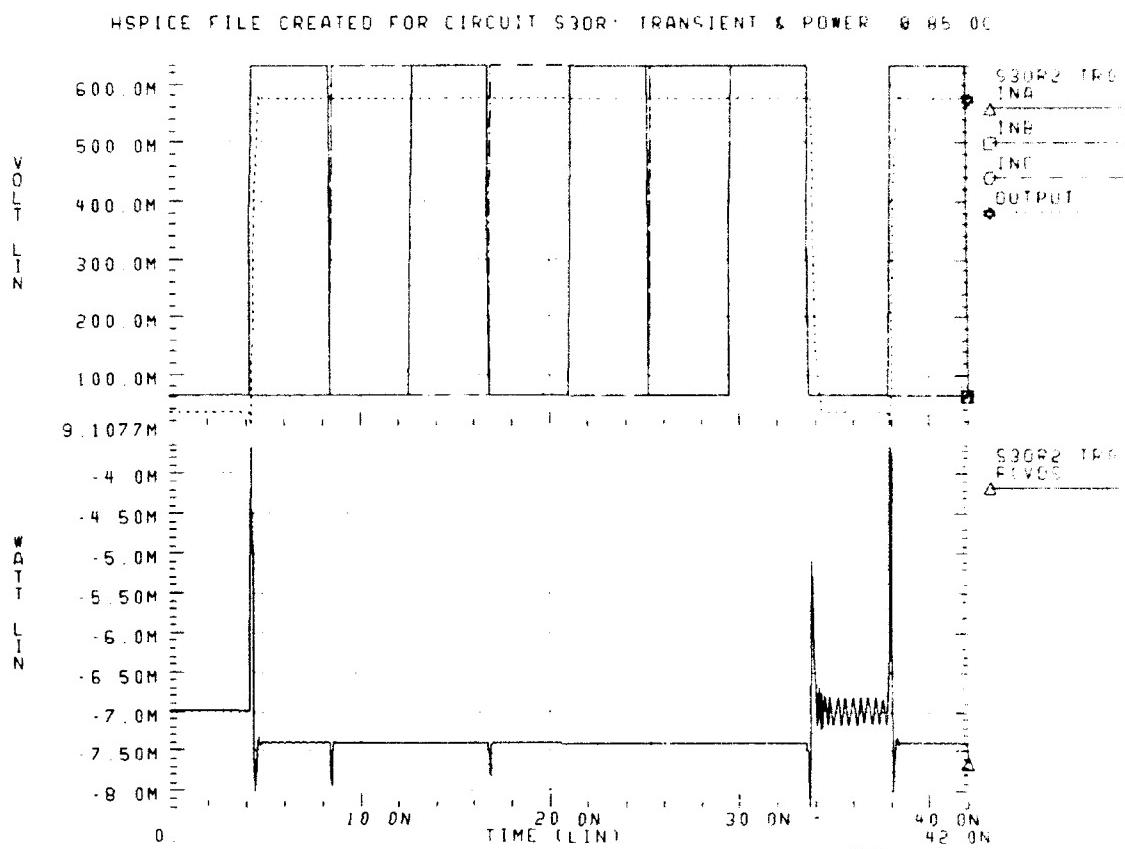


Figure 4.108 S3OR HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the S3OR logic gate operating at a temperature of 25.0C is shown in Figure 4.109 on page 107.

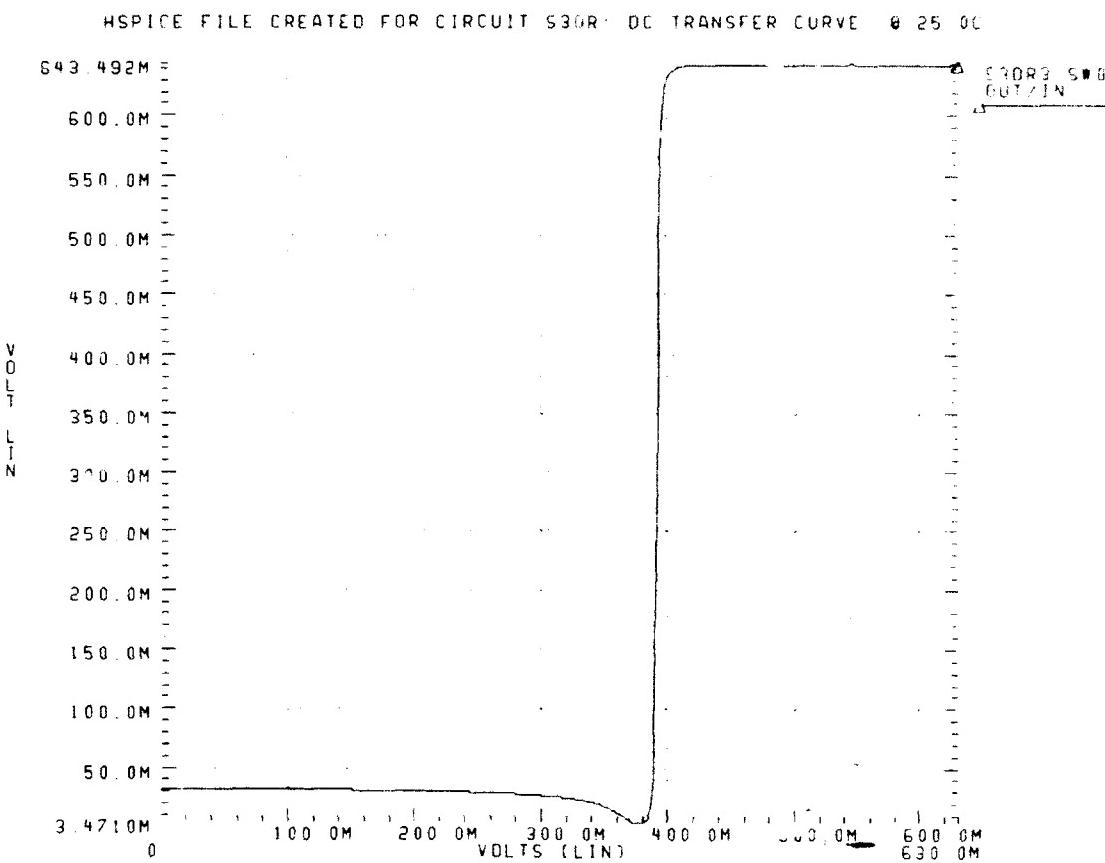


Figure 4.109 S3OR DC Transfer Curve at 25.0C

The DC transfer characteristic of the S3OR logic gate operating at a temperature of 85.0C is shown in Figure 4.110 on page 108.

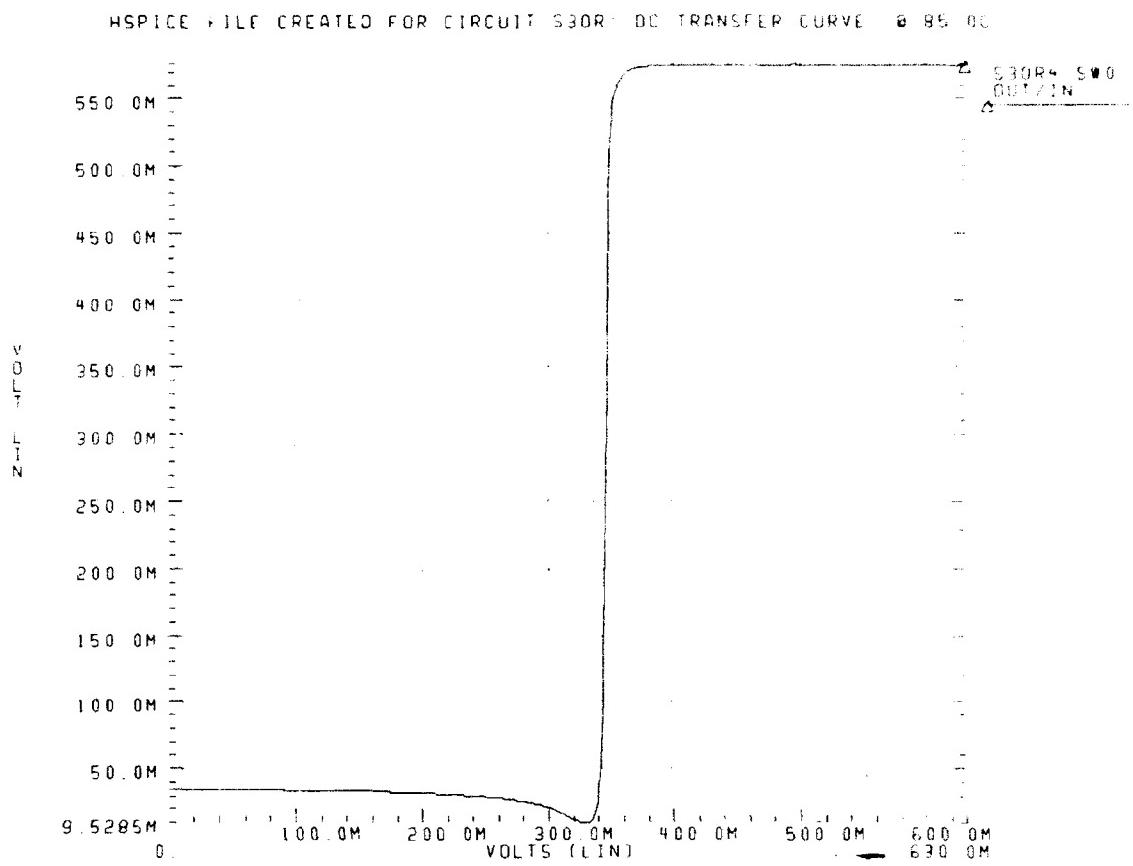


Figure 4.110 S3OR DC Transfer Curve at 85.0C

7. SBFL 2-input NAND Gate (SS2NAND)

The following graphs represent the operating characteristics of the SS2NAND. See Figure 4.111 on page 108 for the SS2NAND schematic and logical equivalence.

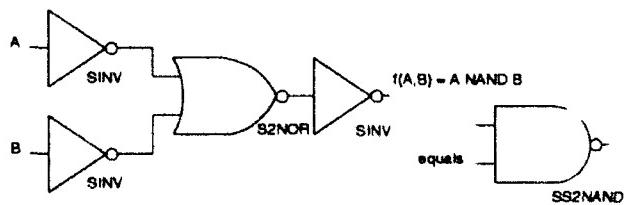


Figure 4.111 Schematic and Logical Equivalence for SS2NAND

The transient analysis and power dissipation of the SS2NAND operating at a temperature of 25.0C is shown in Figure 4.112 on page 109.

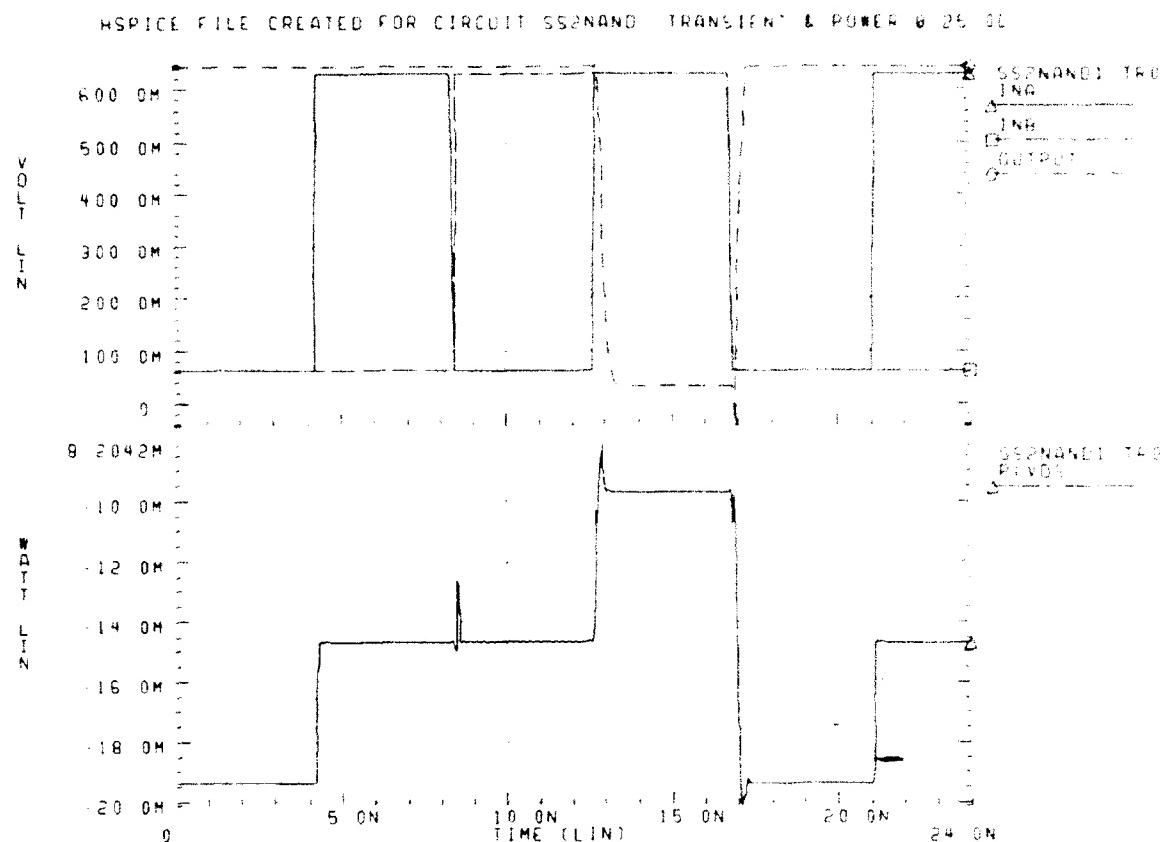


Figure 4.112 SS2NAND HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the SS2NAND operating at a temperature of 85.0C is shown in Figure 4.113 on page 110.

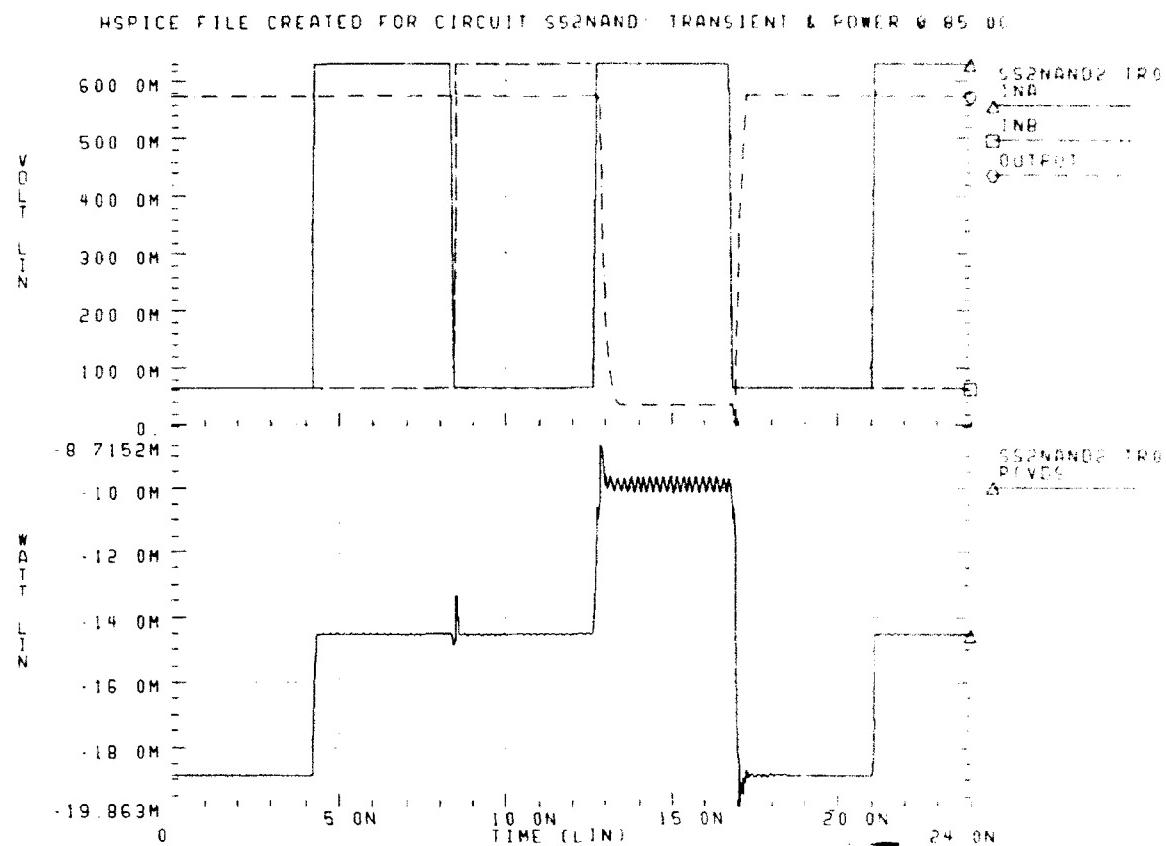


Figure 4.113 SS2NAND HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the SS2NAND logic gate operating at a temperature of 25.0C is shown in Figure 4.114 on page 111.

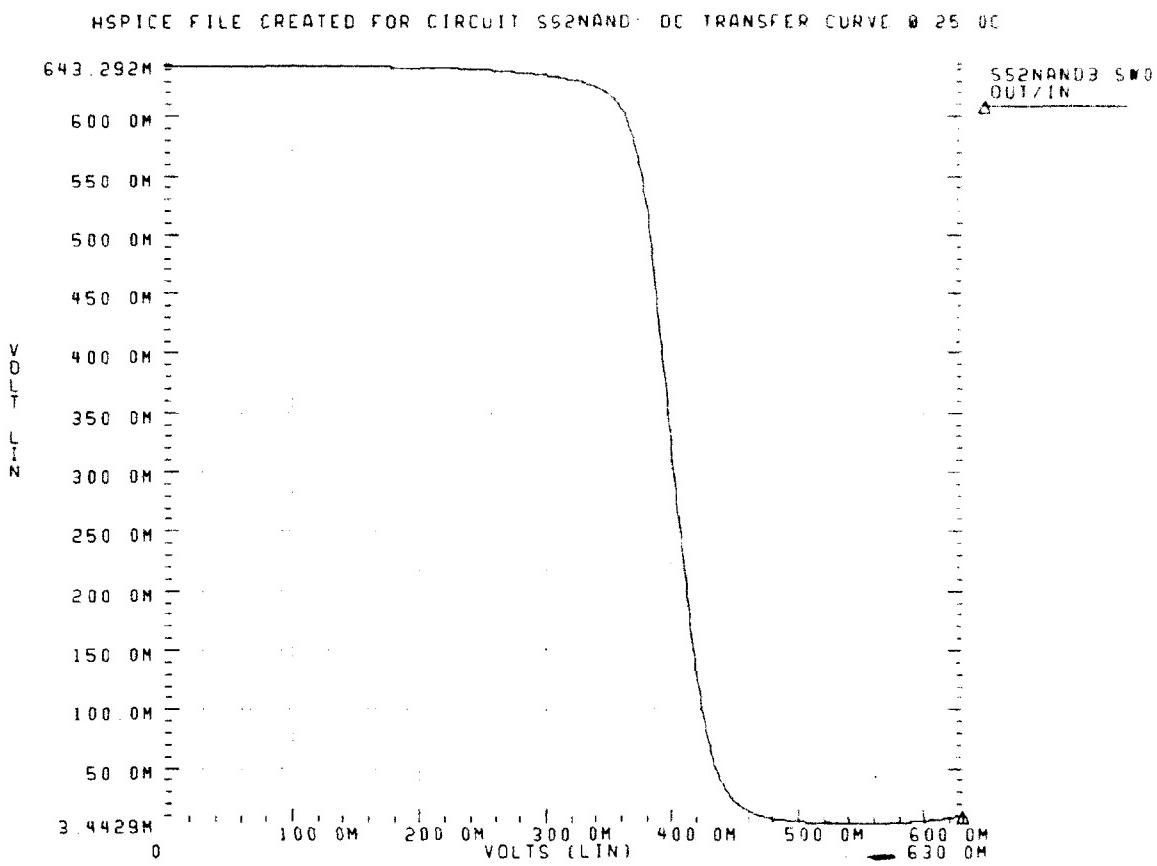


Figure 4.114 SS2NAND DC Transfer Curve at 25.0C

The DC transfer characteristic of the SS2NAND logic gate operating at a temperature of 85.0C is shown in Figure 4.115 on page 112.

HSPICE FILE CREATED FOR CIRCUIT SS2NAND: DC TRANSFER CURVE @ 85.0C

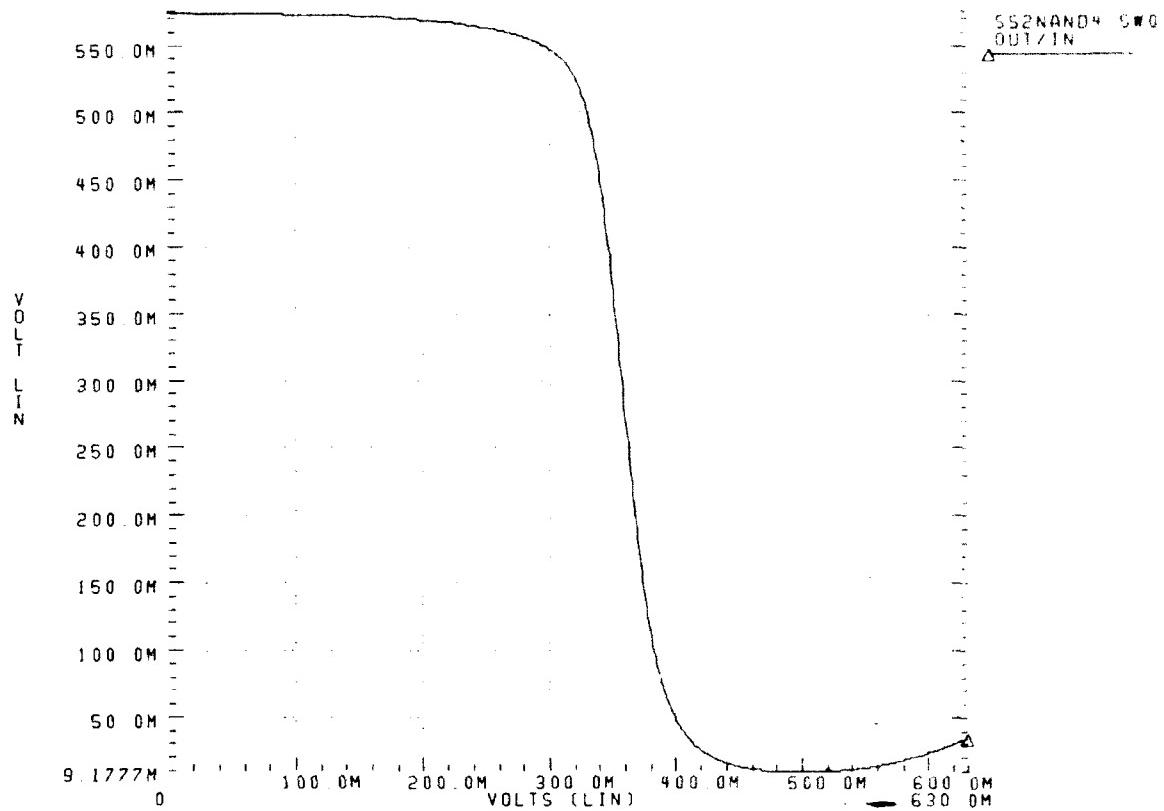


Figure 4.115 SS2NAND DC Transfer Curve at 85.0C

8. SBFL 4-input NAND Gate (SS4NAND)

The following graphs represent the operating characteristics of the SS4NAND. See Figure 4.116 on page 113 for the SS4NAND schematic and logical equivalence.

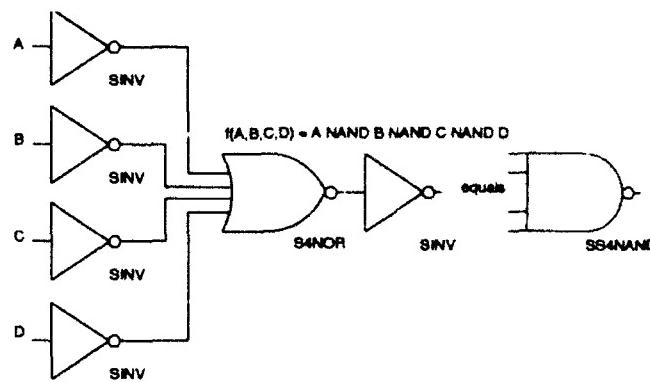


Figure 4.116 Schematic and Logical Equivalence for SS4NAND

The transient analysis and power dissipation of the SS4NAND operating at a temperature of 25.0C is shown in Figure 4.117 on page 113.

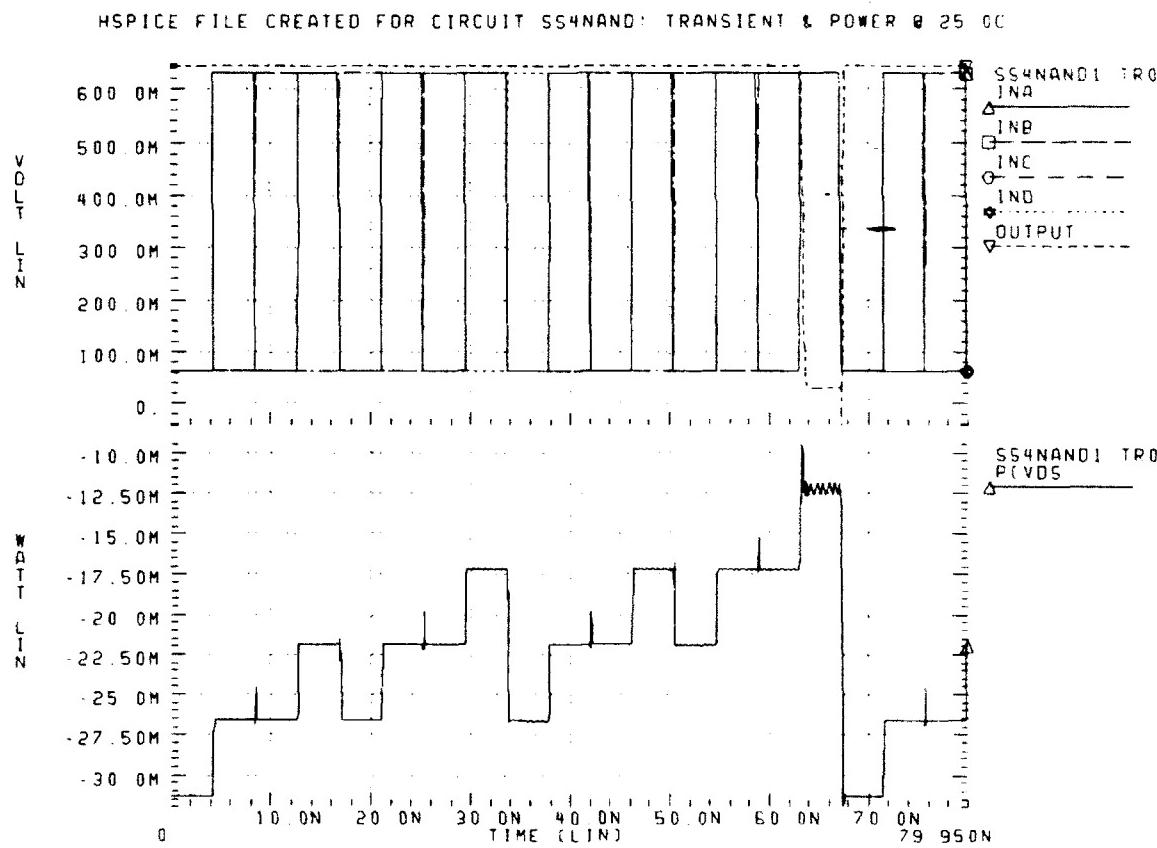


Figure 4.117 SS4NAND HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the SS4NAND operating at a temperature of 85.0C is shown in Figure 4.118 on page 114.

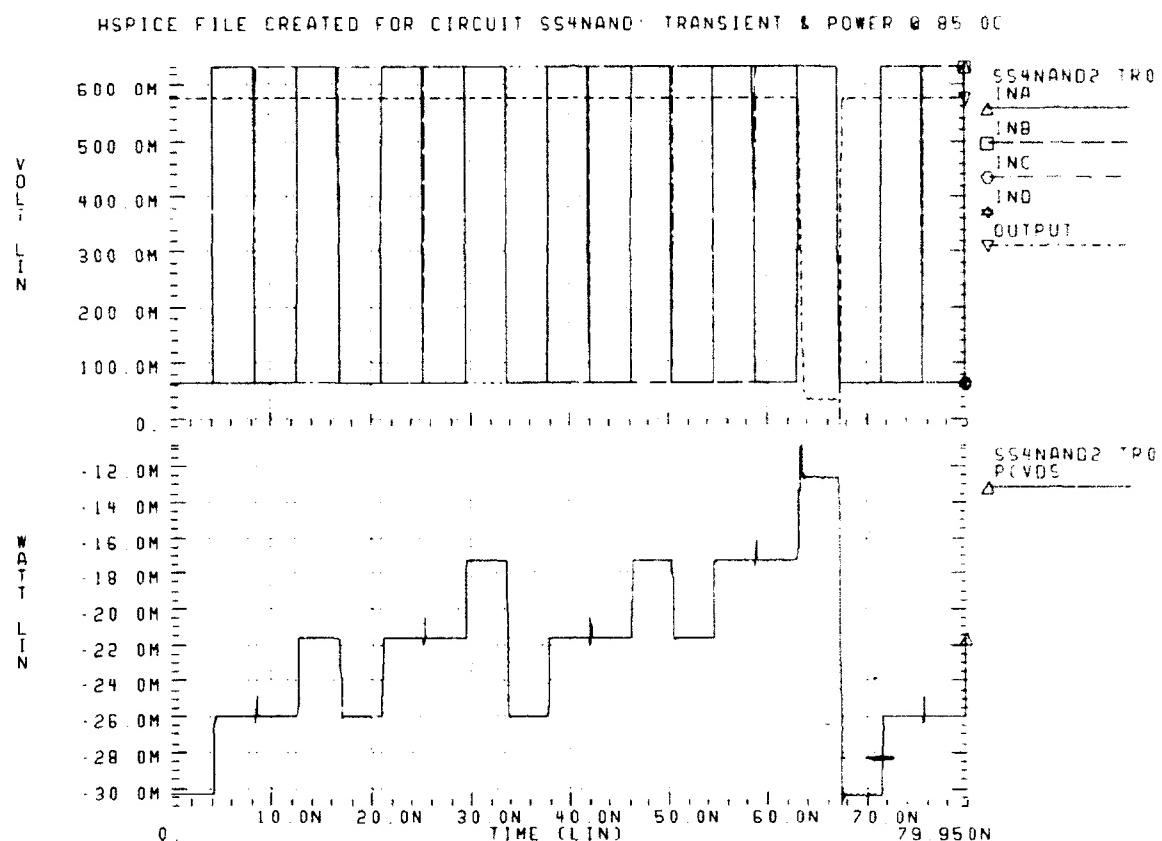


Figure 4.118 SS4NAND HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the SS4NAND logic gate operating at a temperature of 25.0C is shown in Figure 4.119 on page 115.

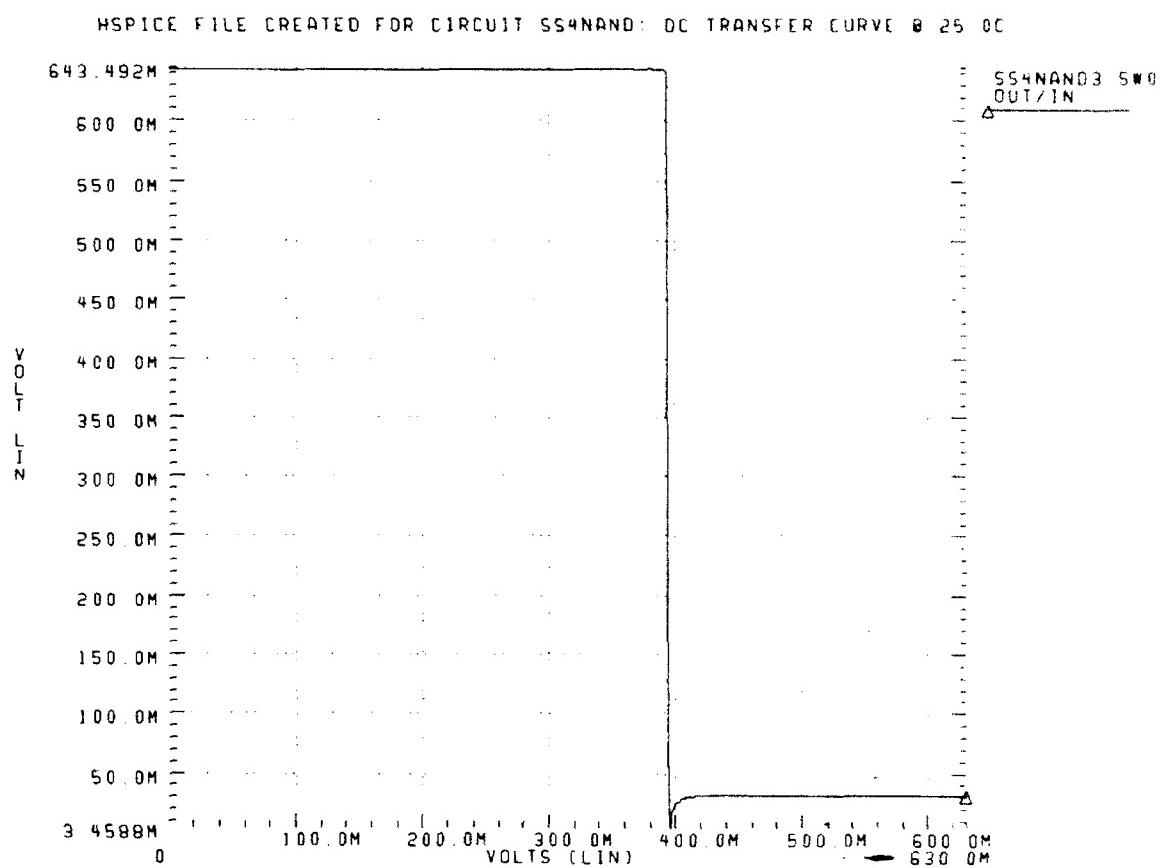


Figure 4.119 SS4NAND DC Transfer Curve at 25.0C

The DC transfer characteristic of the SS4NAND logic gate operating at a temperature of 85.0C is shown in Figure 4.120 on page 116.

HSPICE FILE CREATED FOR CIRCUIT SS4NAND DC TRANSFER CURVE @ 85.0C

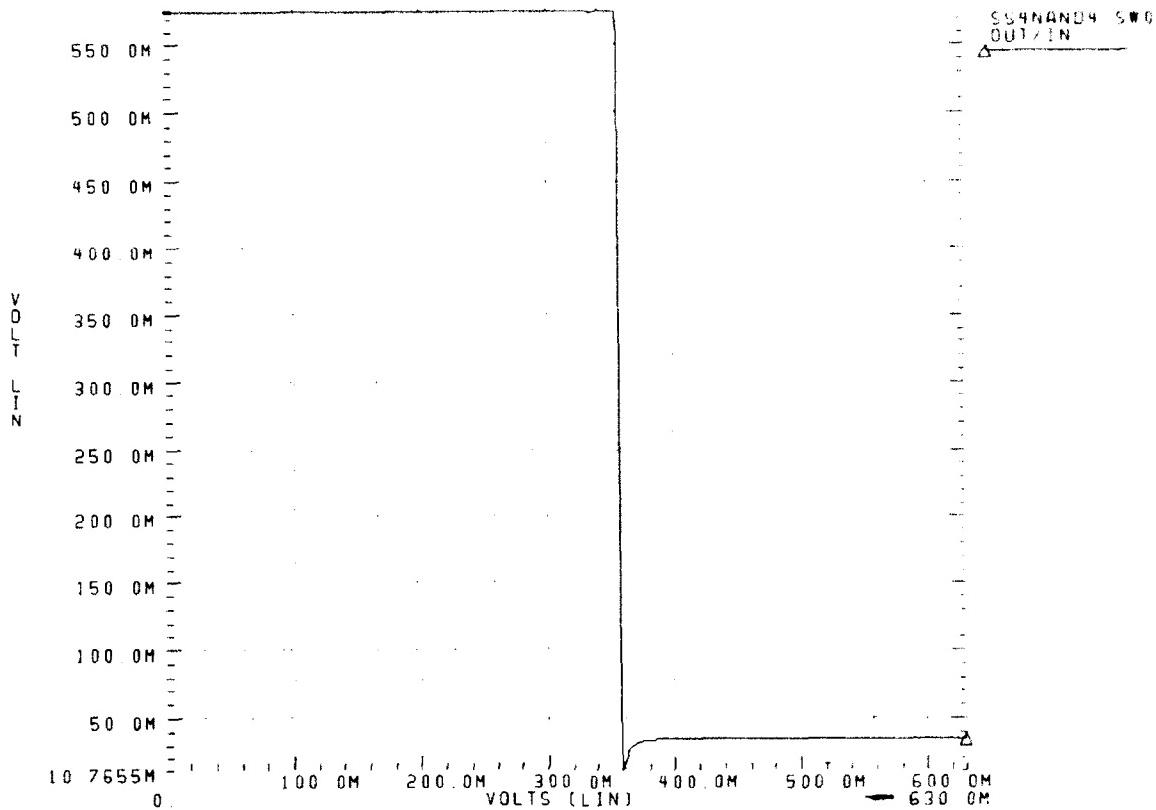


Figure 4.120 SS4NAND DC Transfer Curve at 85.0C

9. SBFL 3-input NAND Gate (SS3AND)

The following graphs represent the operating characteristics of the SS3AND. See Figure 4.121 on page 116 for the SS4NAND schematic and logical equivalence.

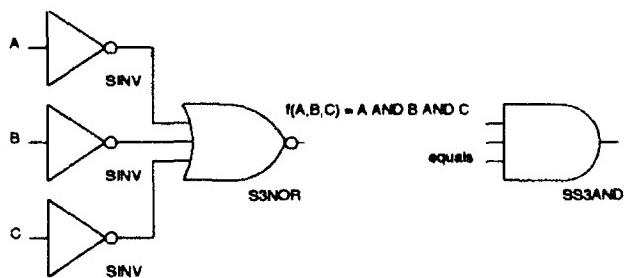


Figure 4.121 Schematic and Logical Equivalence for SS3AND

The transient analysis and power dissipation of the SS3AND operating at a temperature of 25.0C is shown in Figure 4.122 on page 117.

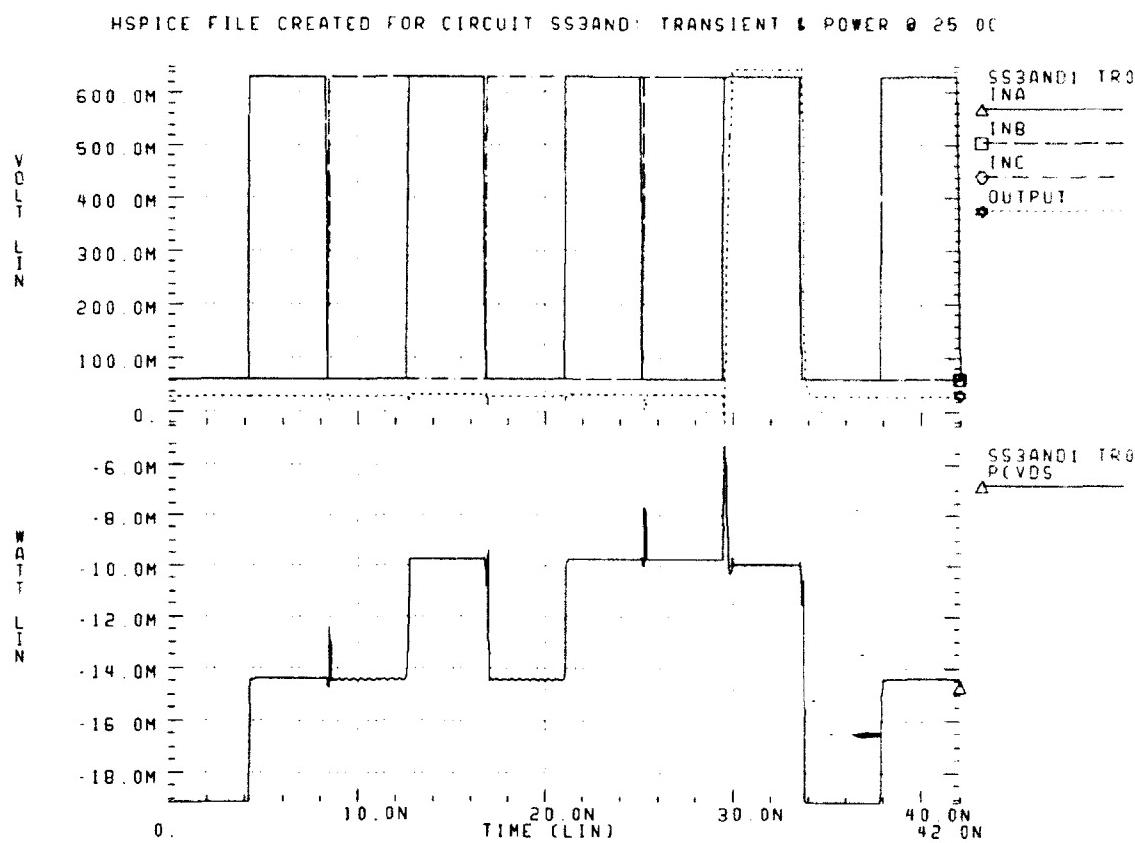


Figure 4.122 SS3AND HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the SS3AND operating at a temperature of 85.0C is shown in Figure 4.123 on page 118.

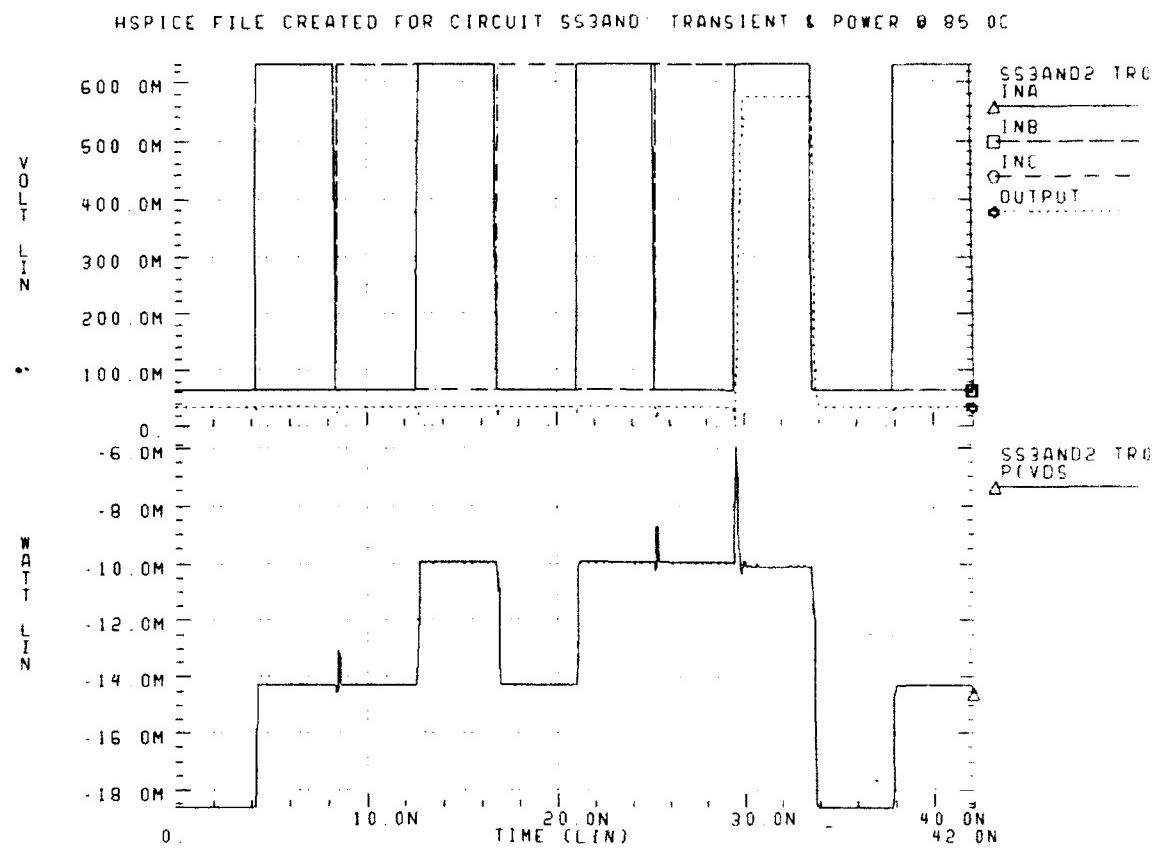


Figure 4.123 SS3AND HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the SS3AND logic gate operating at a temperature of 25.0C is shown in Figure 4.124 on page 119.

HSPICE FILE CREATED FOR CIRCUIT SS3AND: DC TRANSFER CURVE @ 25 0C

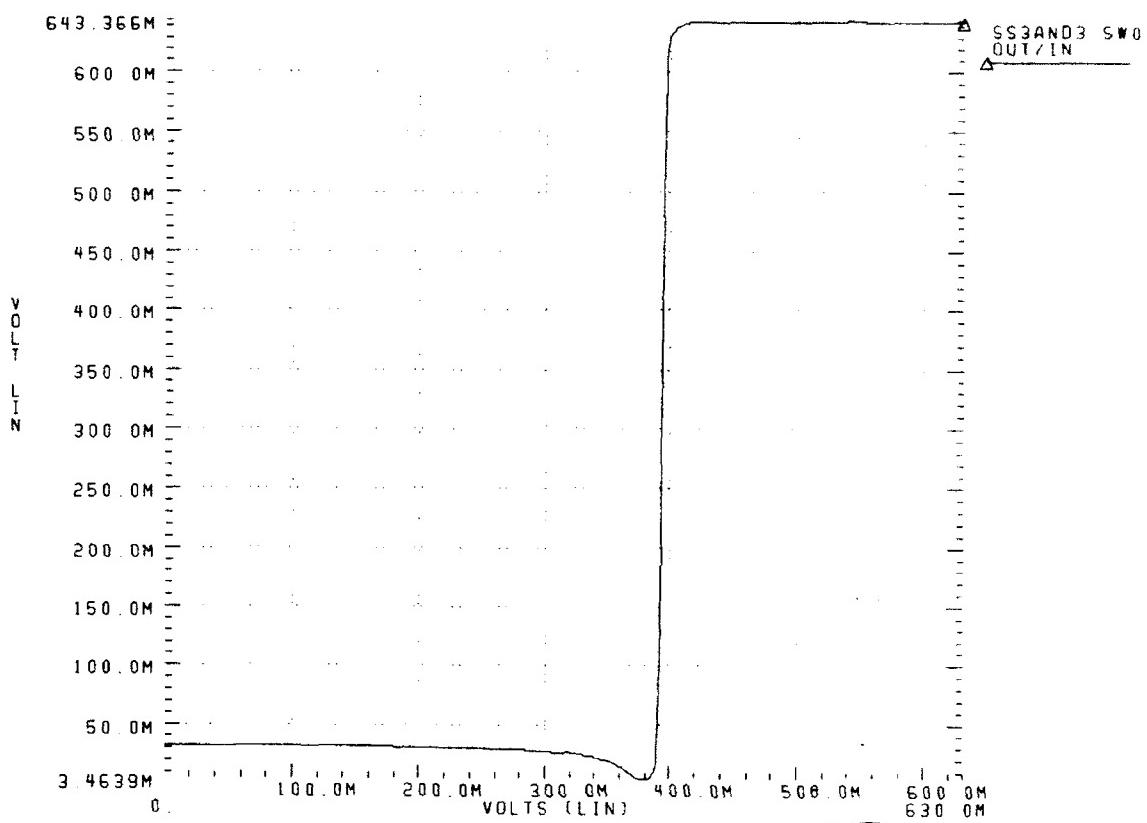


Figure 4.124 SS3AND DC Transfer Curve at 25.0C

The DC transfer characteristic of the SS3AND logic gate operating at a temperature of 85.0C is shown in Figure 4.125 on page 120.

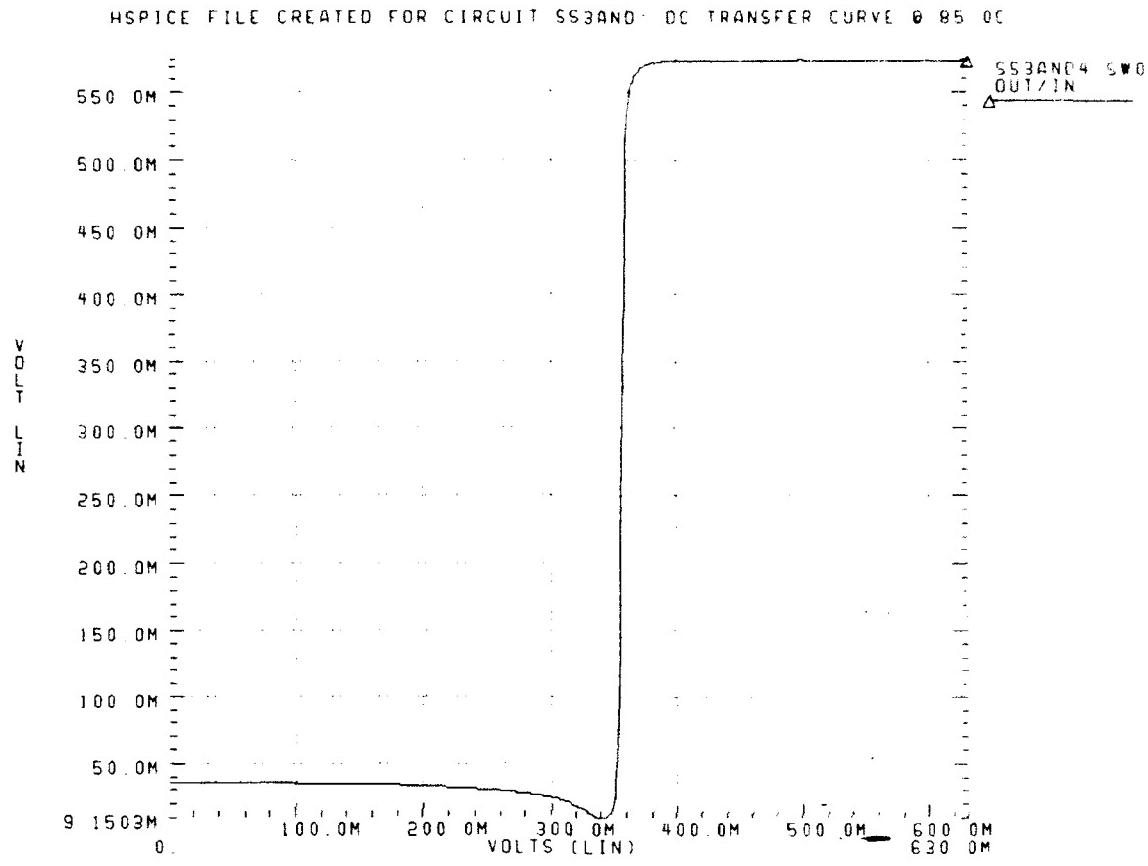


Figure 4.125 SS3AND DC Transfer Curve at 85.0C

10. SBFL 4-input NAND Gate (SS4AND)

The following graphs represent the operating characteristics of the SS4AND. See Figure 4.126 on page 121 for the SS4NAND schematic and logical equivalence.

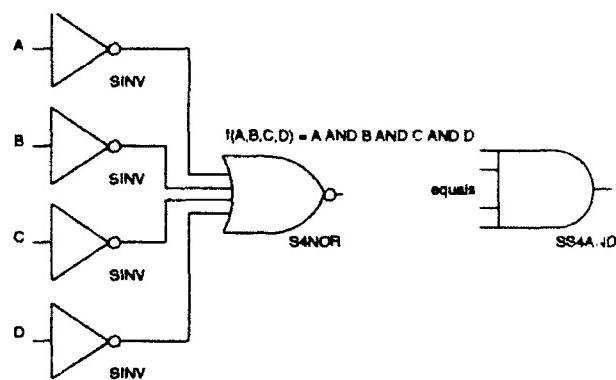


Figure 4.126 Schematic and Logica! Equivalence for SS4AND

The transient analysis and power dissipation of the SS4AND operating at a temperature of 25.0C is shown in Figure 4.127 on page 121.

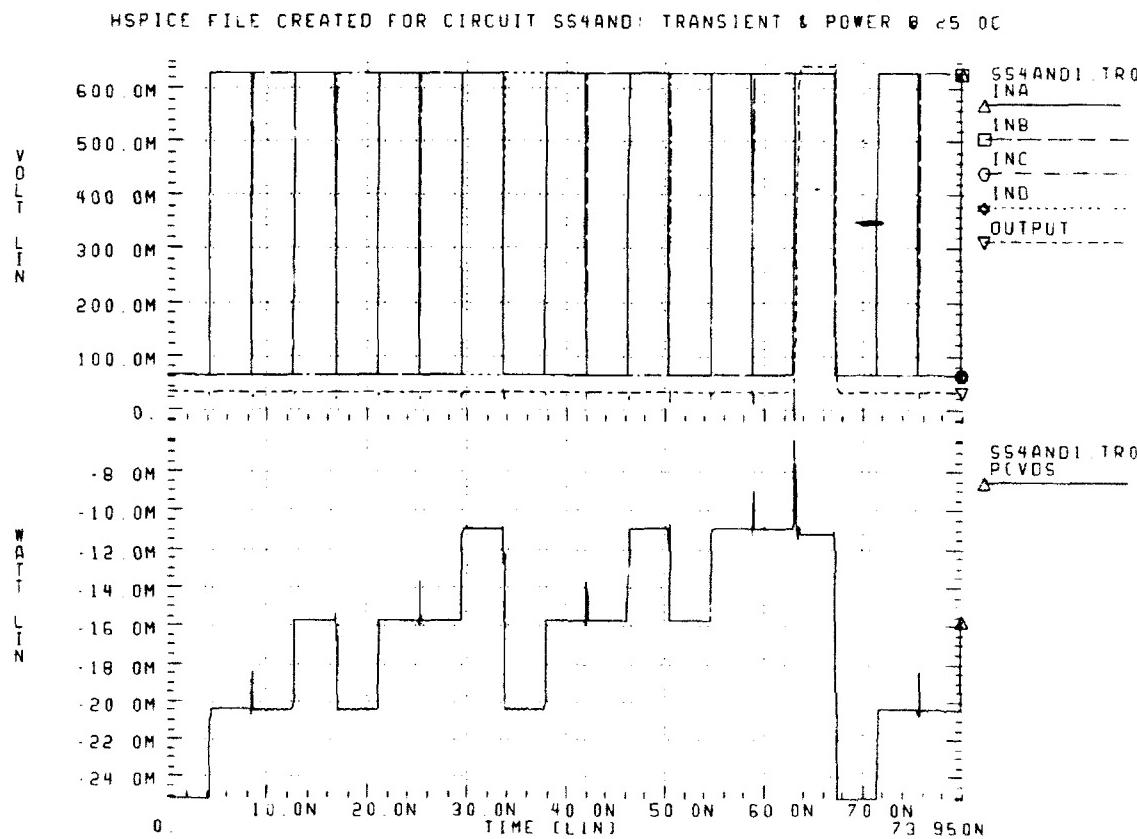


Figure 4.127 SS4AND HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the SS4AND operating at a temperature of 85.0C is shown in Figure 4.128 on page 122.

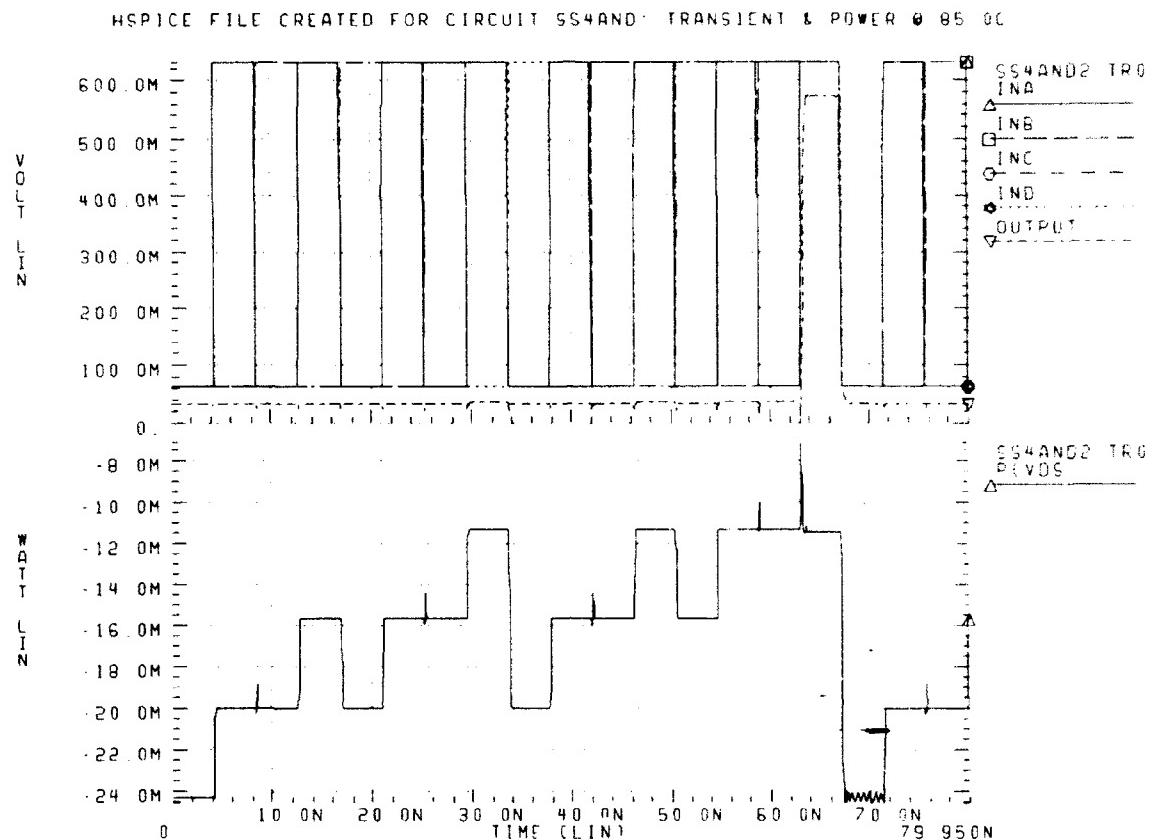


Figure 4.128 SS4AND HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the SS4AND logic gate operating at a temperature of 25.0C is shown in Figure 4.129 on page 123.

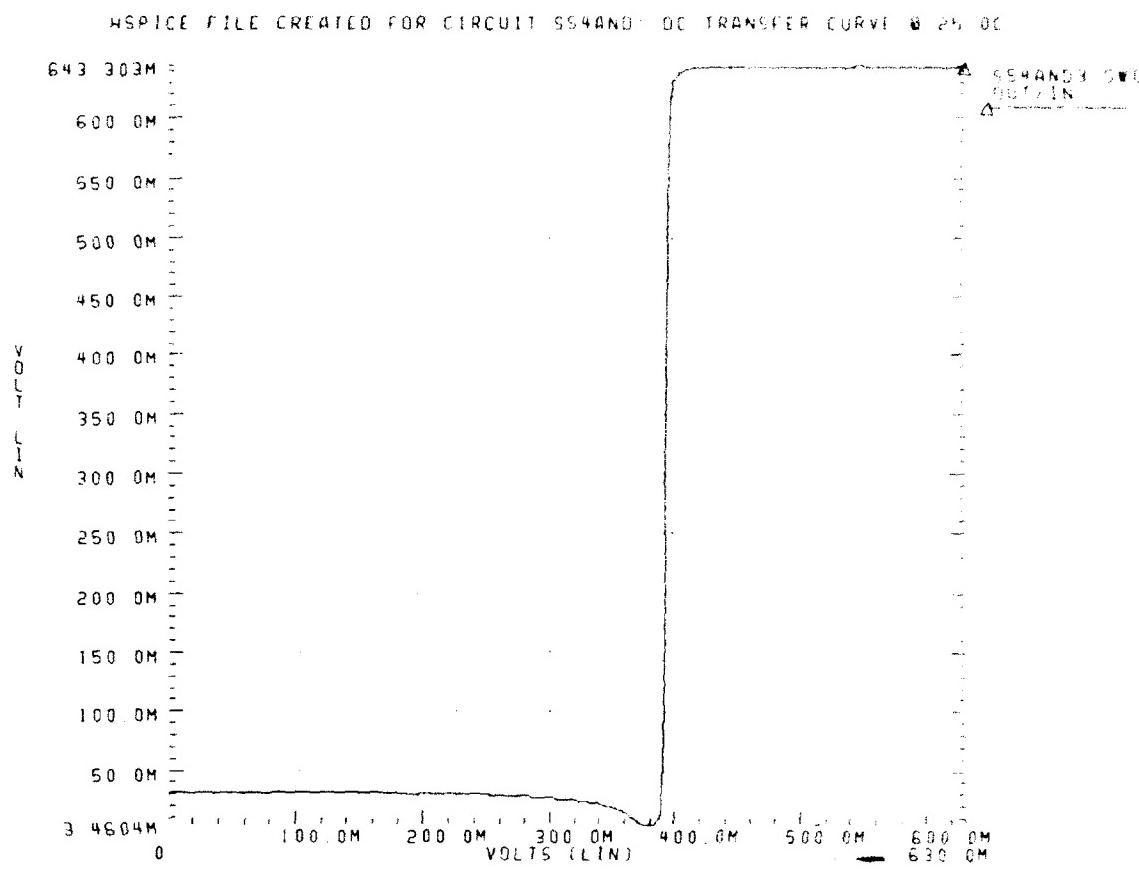


Figure 4.129 SS4AND DC Transfer Curve at 25.0C

The DC transfer characteristic of the SS4AND logic gate operating at a temperature of 85.0C is shown in Figure 4.130 on page 124.

HSPICE FILE CREATED FOR CIRCUIT SS4AND DC TRANSFER CURVE @ 85.0C

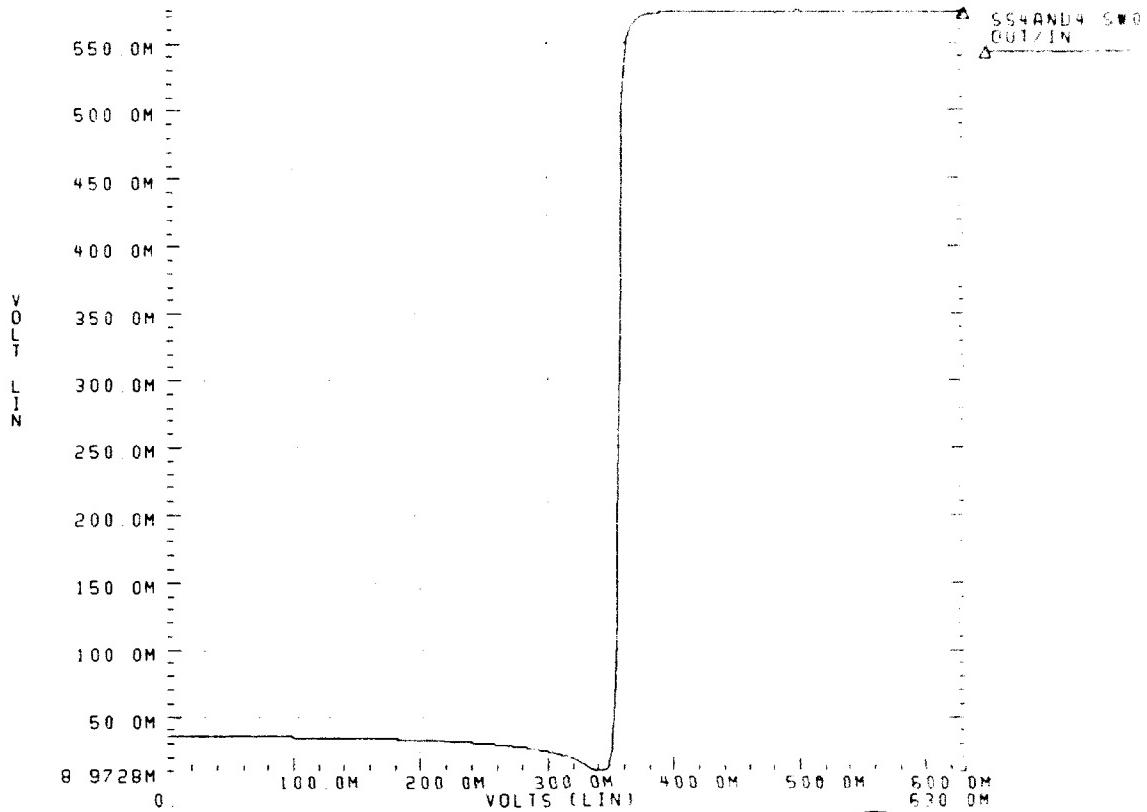


Figure 4.130 SS4AND DC Transfer Curve at 85.0C

11. SBFL 2-input NOR Gate (BS2NOR)

The following graphs represent the operating characteristics of the BS2NOR. This logic element was designed specifically for use in the BS2AND which is then used in the DELAY circuit. Notice the unusual MESFET size ratios. See Figure 4.131 on page 125 for the BS2NOR schematic and logical equivalence.

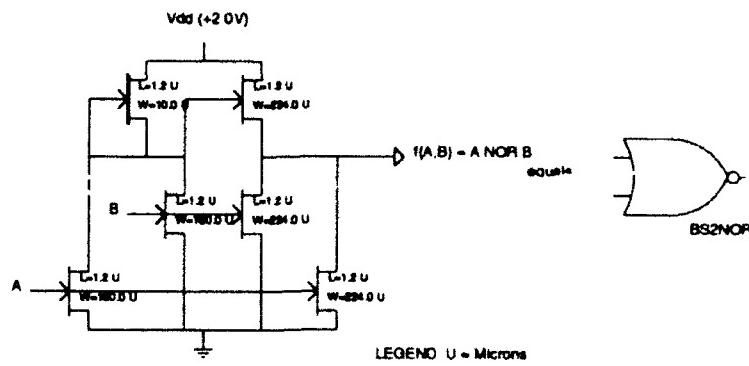


Figure 4.131 Schematic and Logical Equivalence for BS2NOR

The transient analysis and power dissipation of the BS2NOR operating at a temperature of 25.0C is shown in Figure 4.132 on page 125.

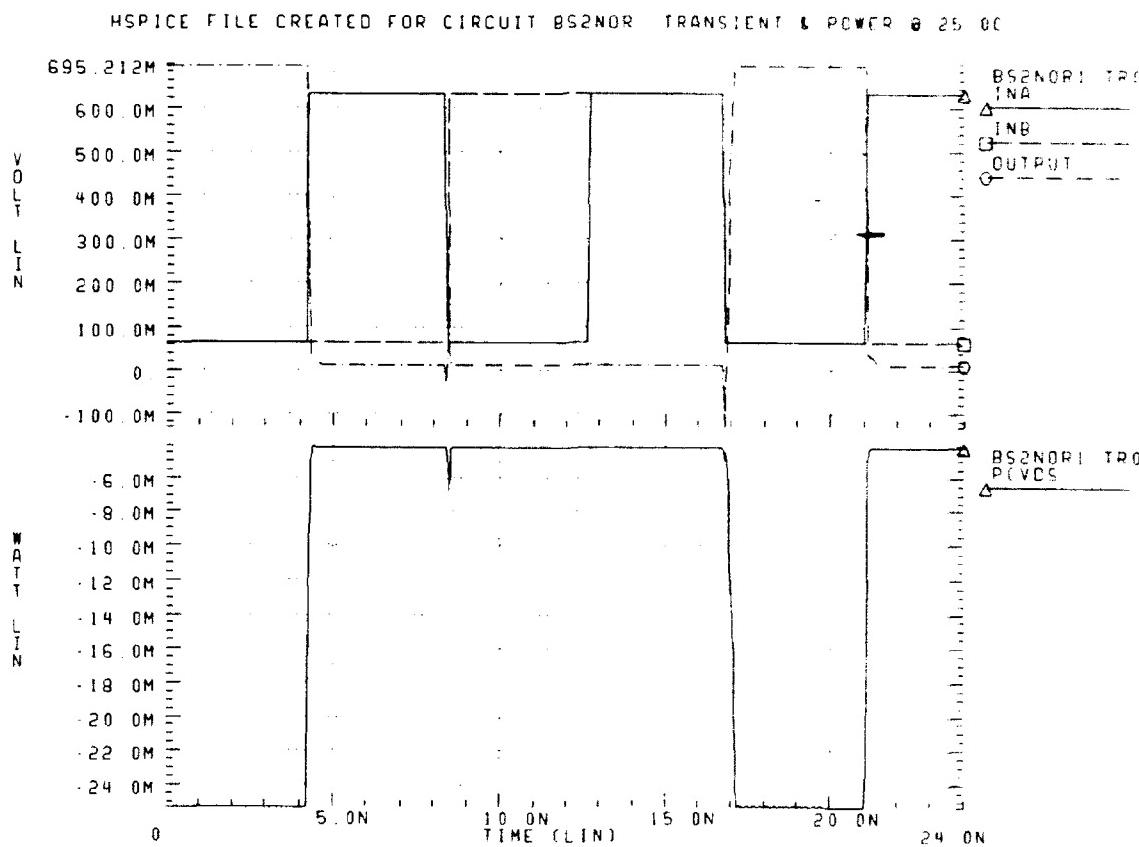


Figure 4.132 BS2NOR HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the BS2NOR operating at a temperature of 85.0C is shown in Figure 4.133 on page 126.

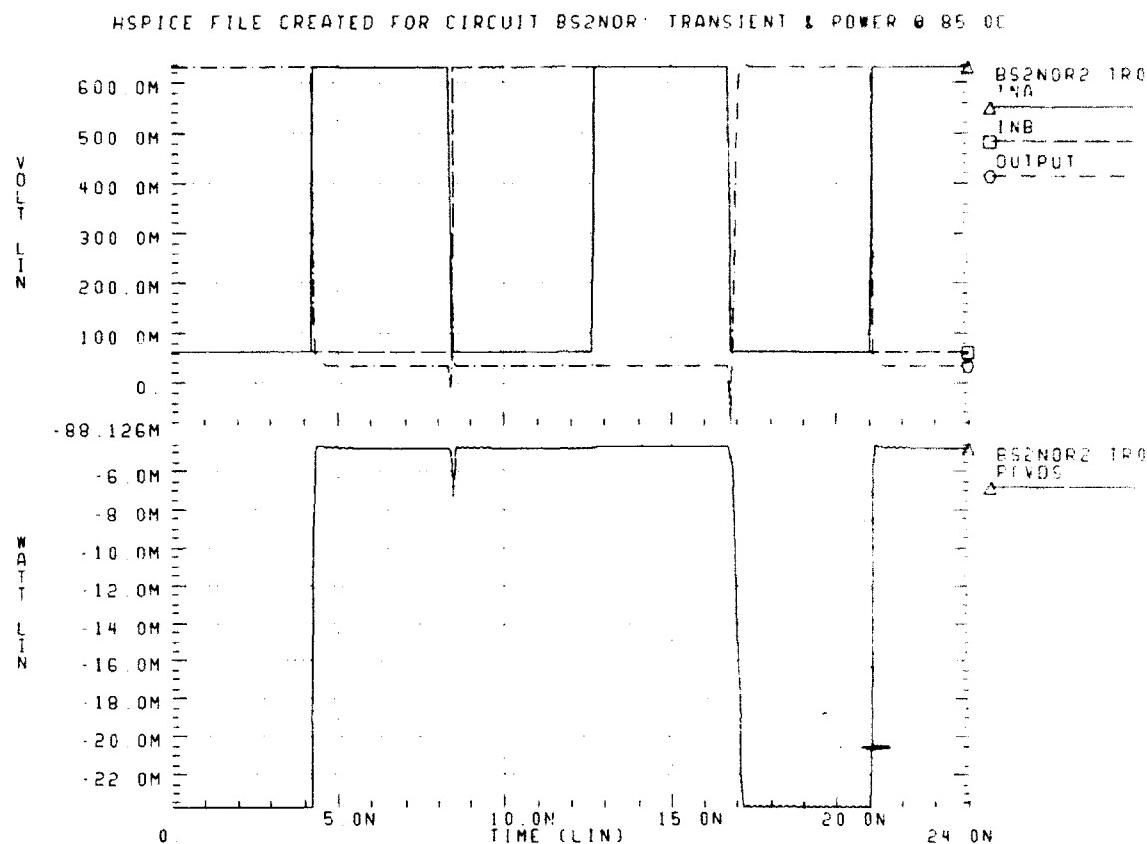


Figure 4.133 BS2NOR HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the BS2NOR logic gate operating at a temperature of 25.0C is shown in Figure 4.134 on page 127.

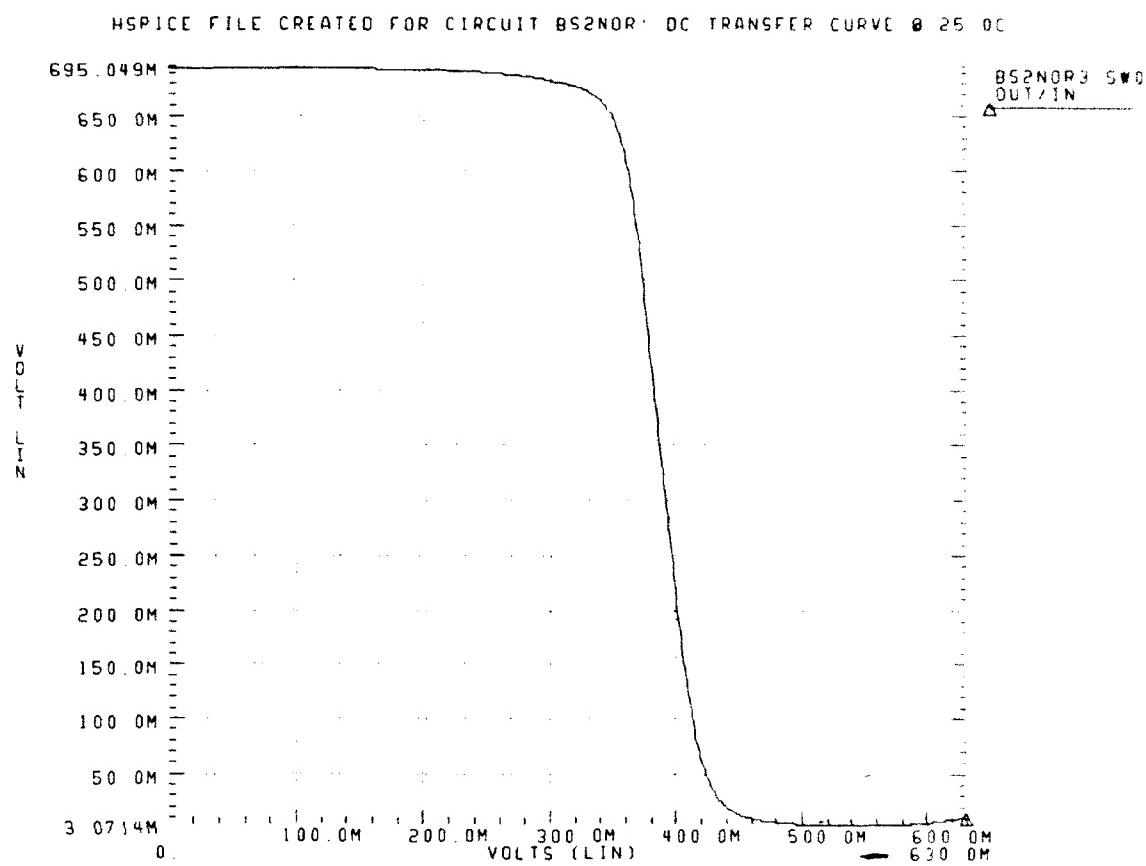


Figure 4.134 BS2NOR DC Transfer Curve at 25.0C

The DC transfer characteristic of the BS2NOR logic gate operating at a temperature of 85.0C is shown in Figure 4.135 on page 128.

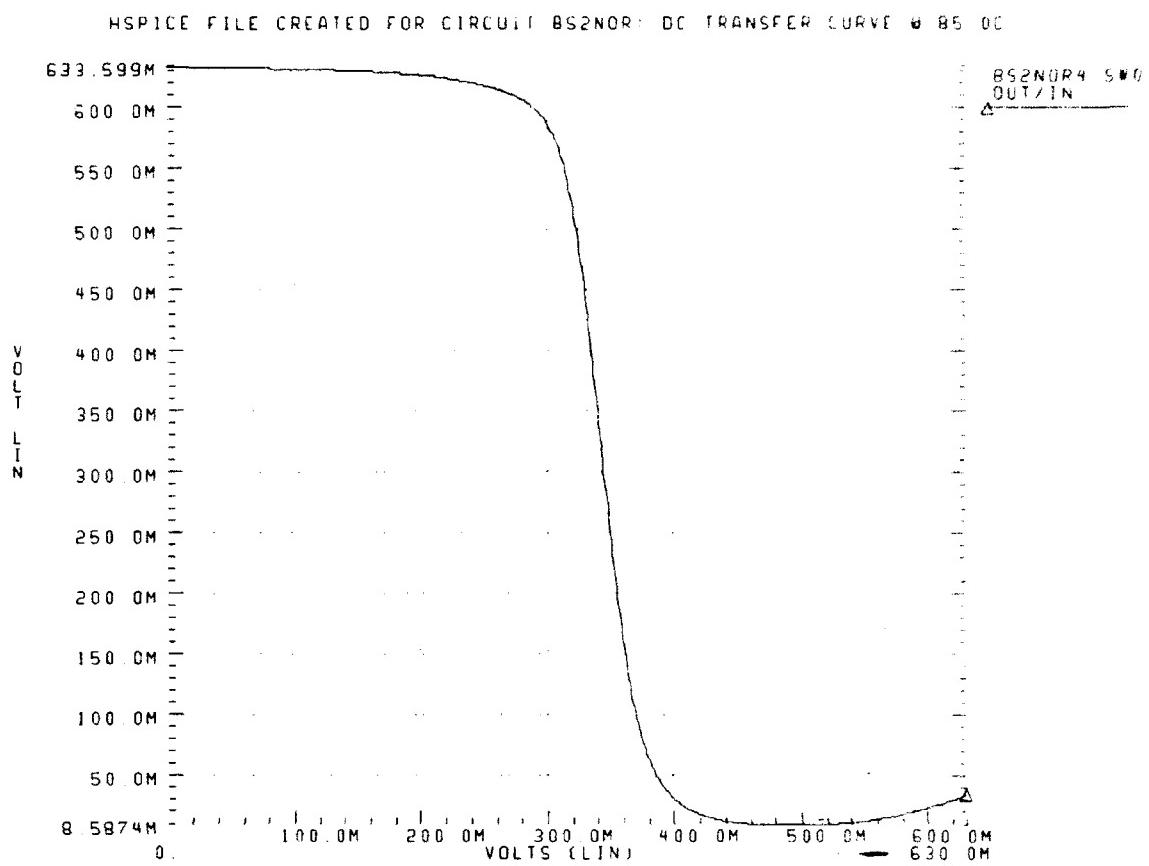


Figure 4.135 BS2NOR DC Transfer Curve at 85.0C

12. SBFL INVERTER (CSINV)

The following graphs represent the operating characteristics of the CSINV. This logic element was designed specifically for use in the CLOCK circuit. Notice the unusual MESFET size ratios. See Figure 4.136 on page 129 for the CSINV schematic and logical equivalence.

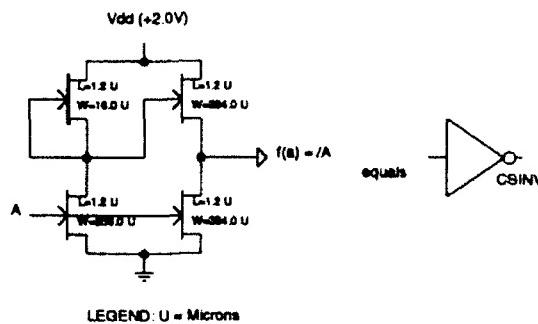


Figure 4.136 Schematic and Logical Equivalence for CSINV

The transient analysis and power dissipation of the CSINV operating at a temperature of 25.0C is shown in Figure 4.137 on page 129.

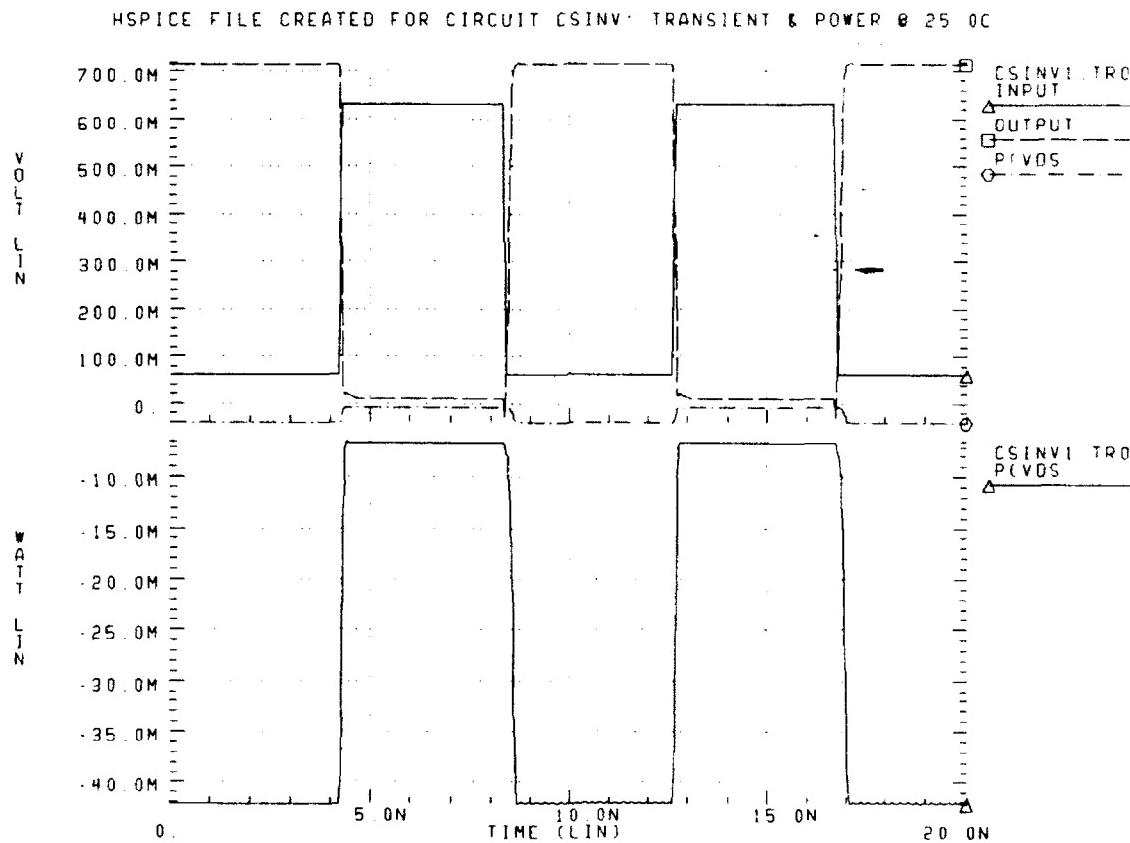


Figure 4.137 CSINV HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the CSINV operating at a temperature of 85.0C is shown in Figure 4.138 on page 130.

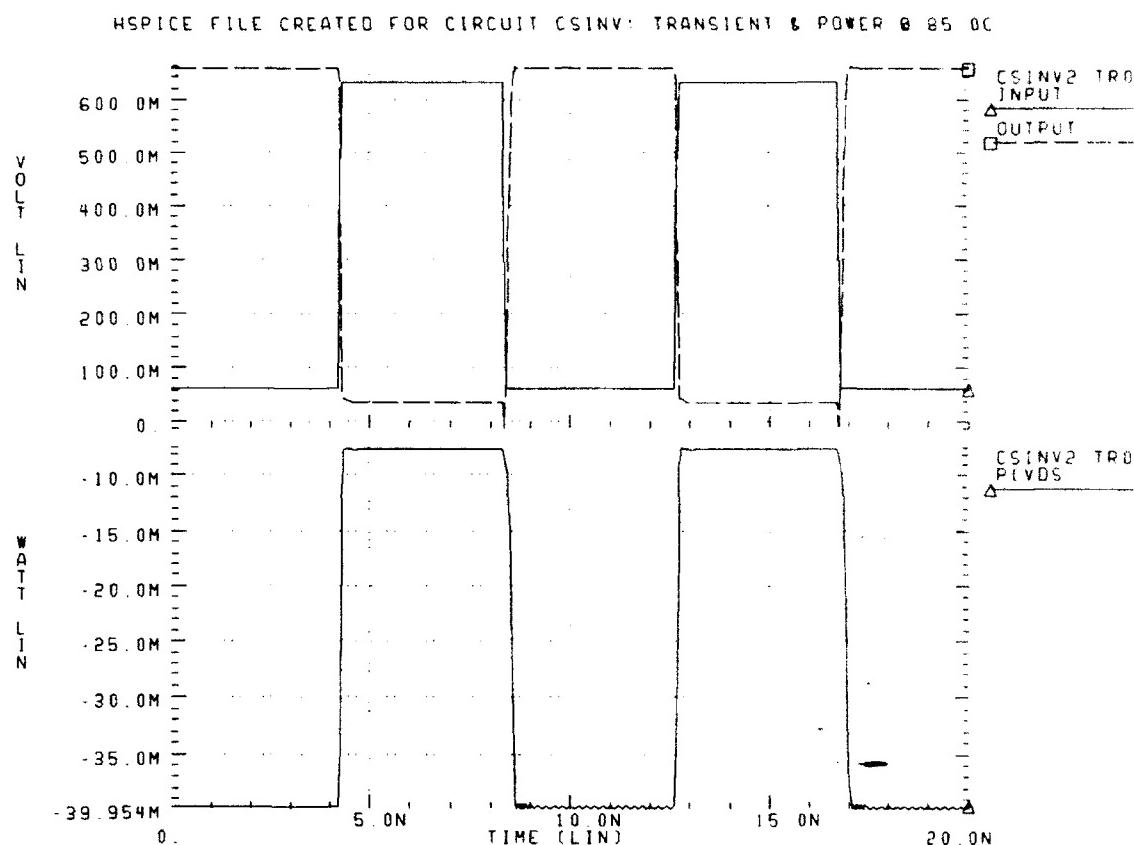


Figure 4.138 CSINV HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the CSINV logic gate operating at a temperature of 25.0C is shown in Figure 4.139 on page 131.

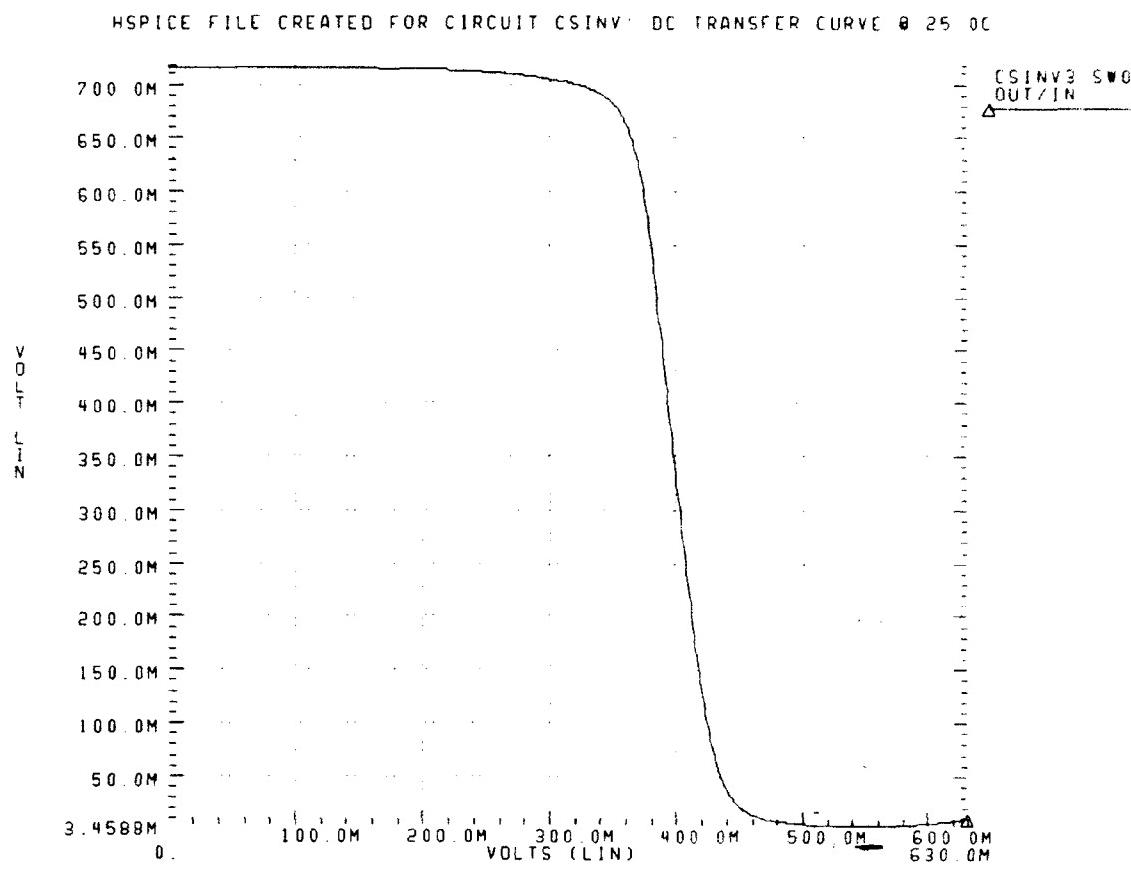


Figure 4.139 CSINV DC Transfer Curve at 25.0C

The DC transfer characteristic of the CSINV logic gate operating at a temperature of 85.0C is shown in Figure 4.140 on page 132.

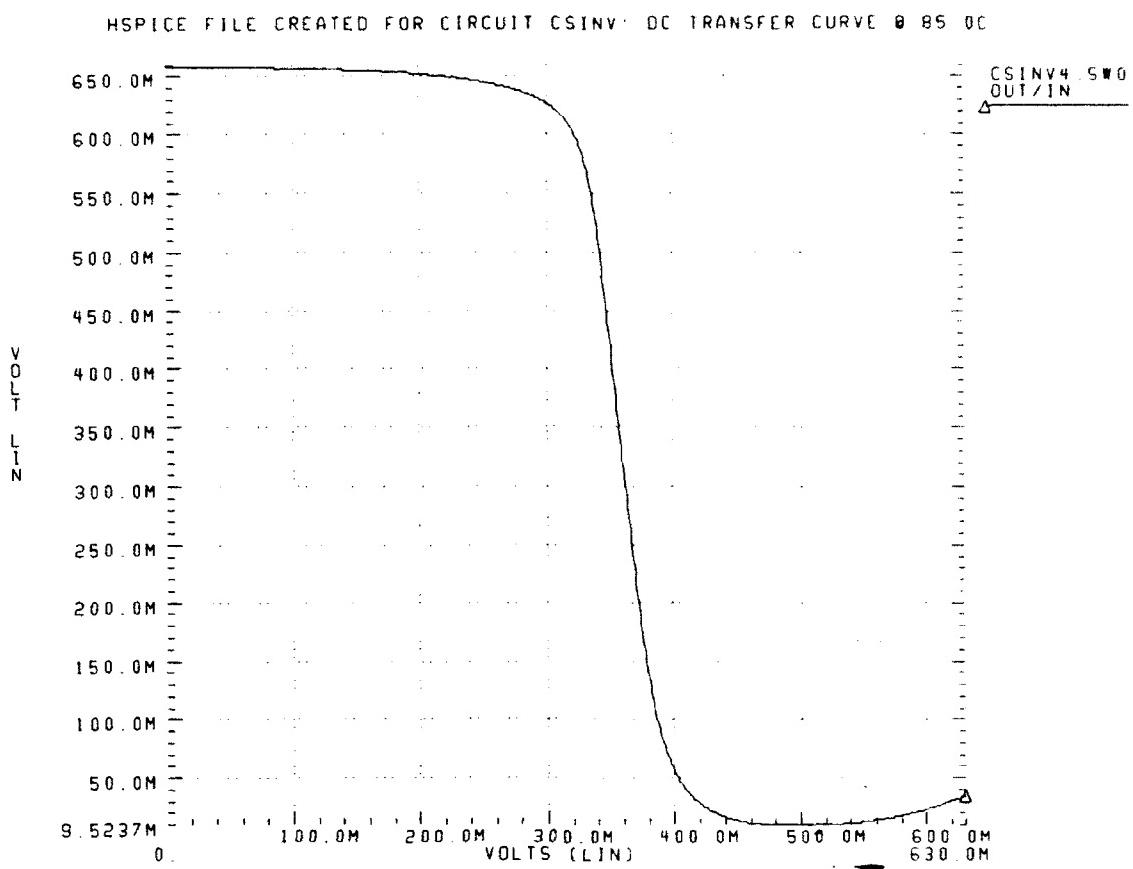


Figure 4.140 CSINV DC Transfer Curve at 85.0C

13. SBFL 2-input NOR Gate (CSNOR)

The following graphs represent the operating characteristics of the CSNOR. This logic element was designed specifically for use in the CLOCK circuit. Notice the unusual MESFET size ratios. See Figure 4.141 on page 133 for the BS2NOR schematic and logical equivalence.

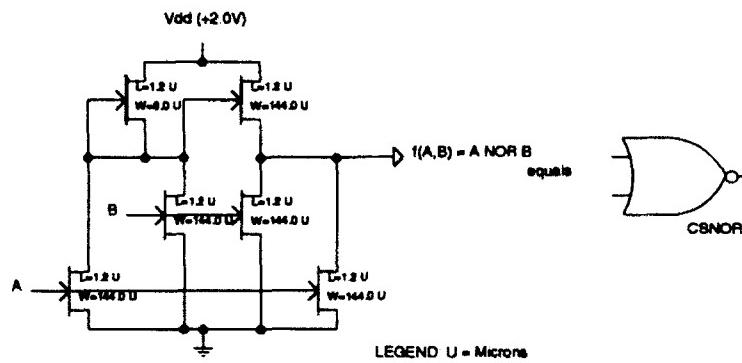


Figure 4.141 Schematic and Logical Equivalence for CSNOR

The transient analysis and power dissipation of the CSNOR operating at a temperature of 25.0C is shown in Figure 4.142 on page 133.

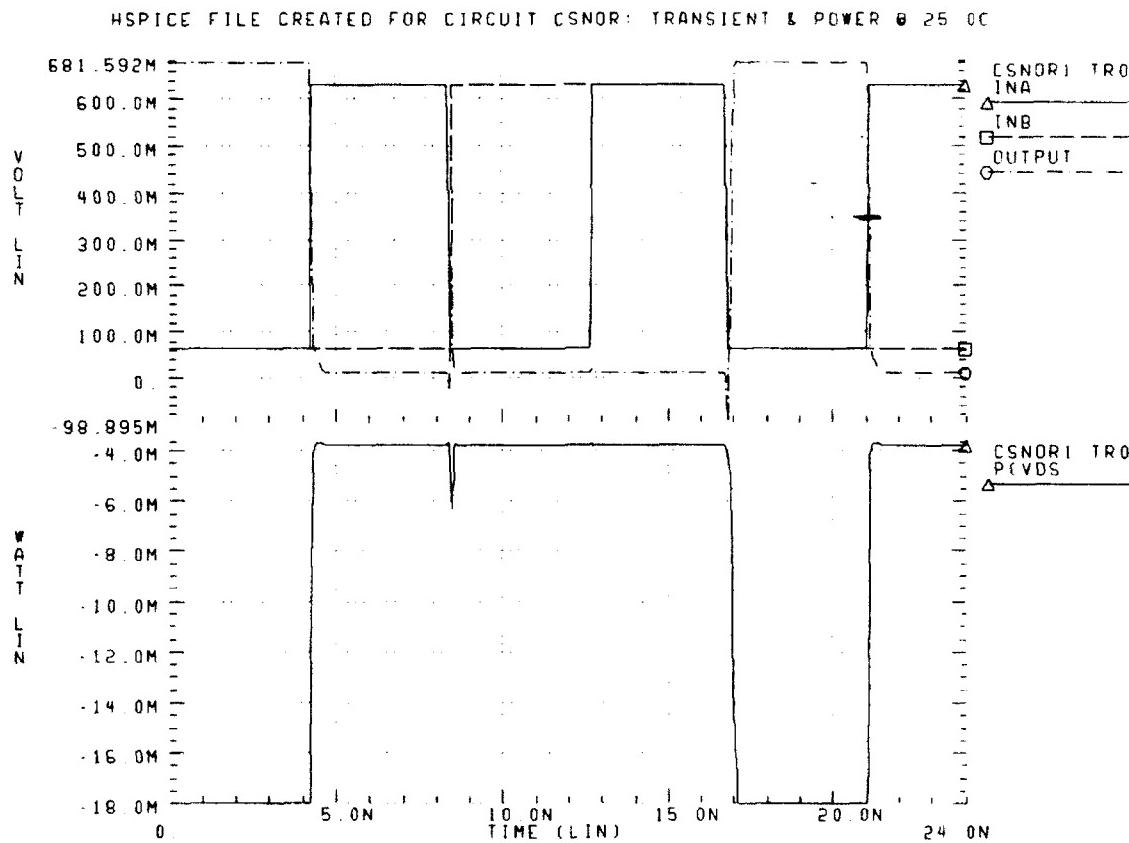


Figure 4.142 CSNOR HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the CSNOR operating at a temperature of 85.0C is shown in Figure 4.143 on page 134.

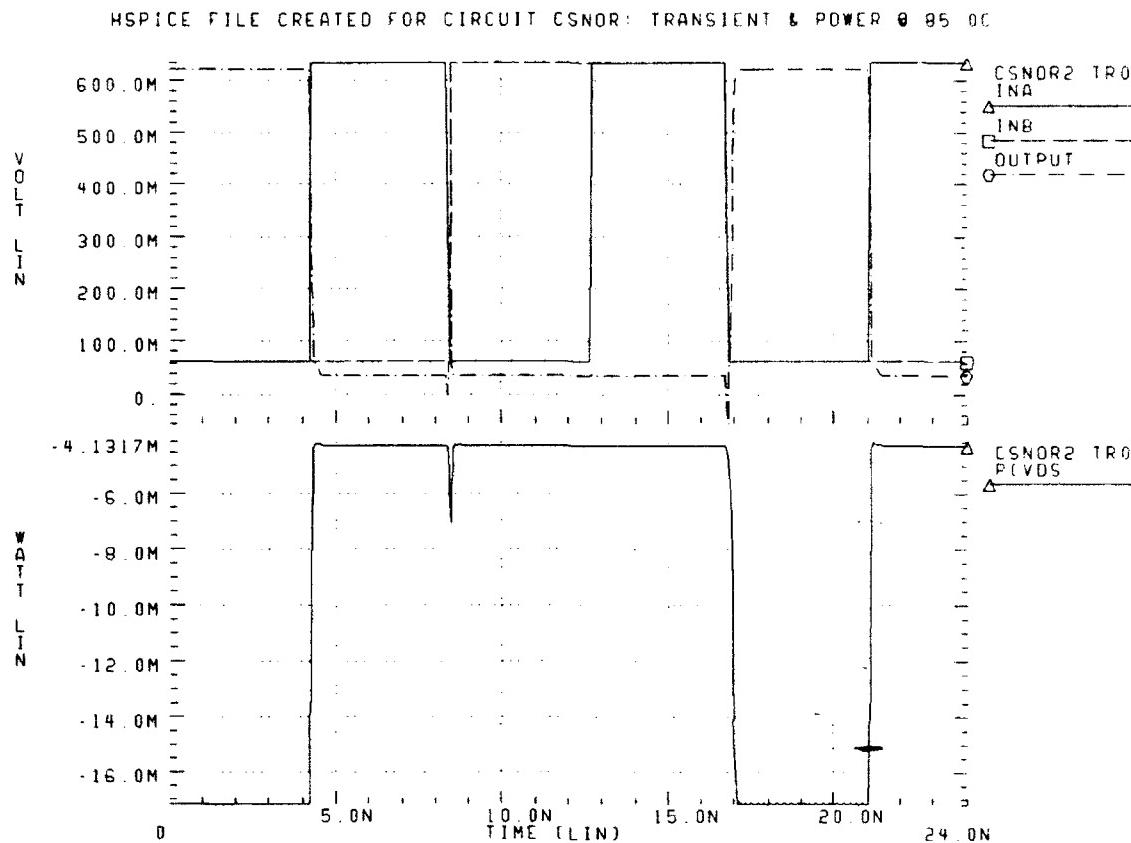


Figure 4.143 CSNOR HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the CSNOR logic gate operating at a temperature of 25.0C is shown in Figure 4.144 on page 135.

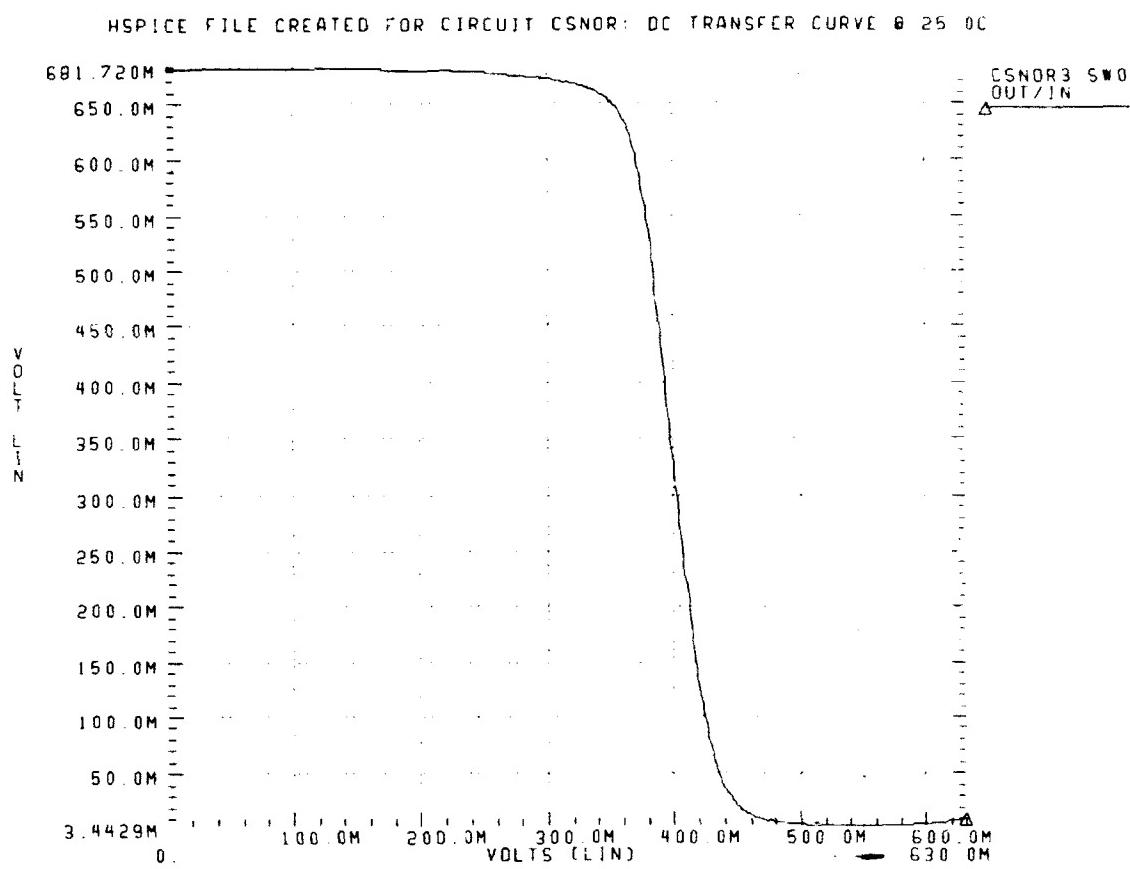


Figure 4.144 CSNOR DC Transfer Curve at 25.0C

The DC transfer characteristic of the CSNOR logic gate operating at a temperature of 85.0C is shown in Figure 4.145 on page 136.

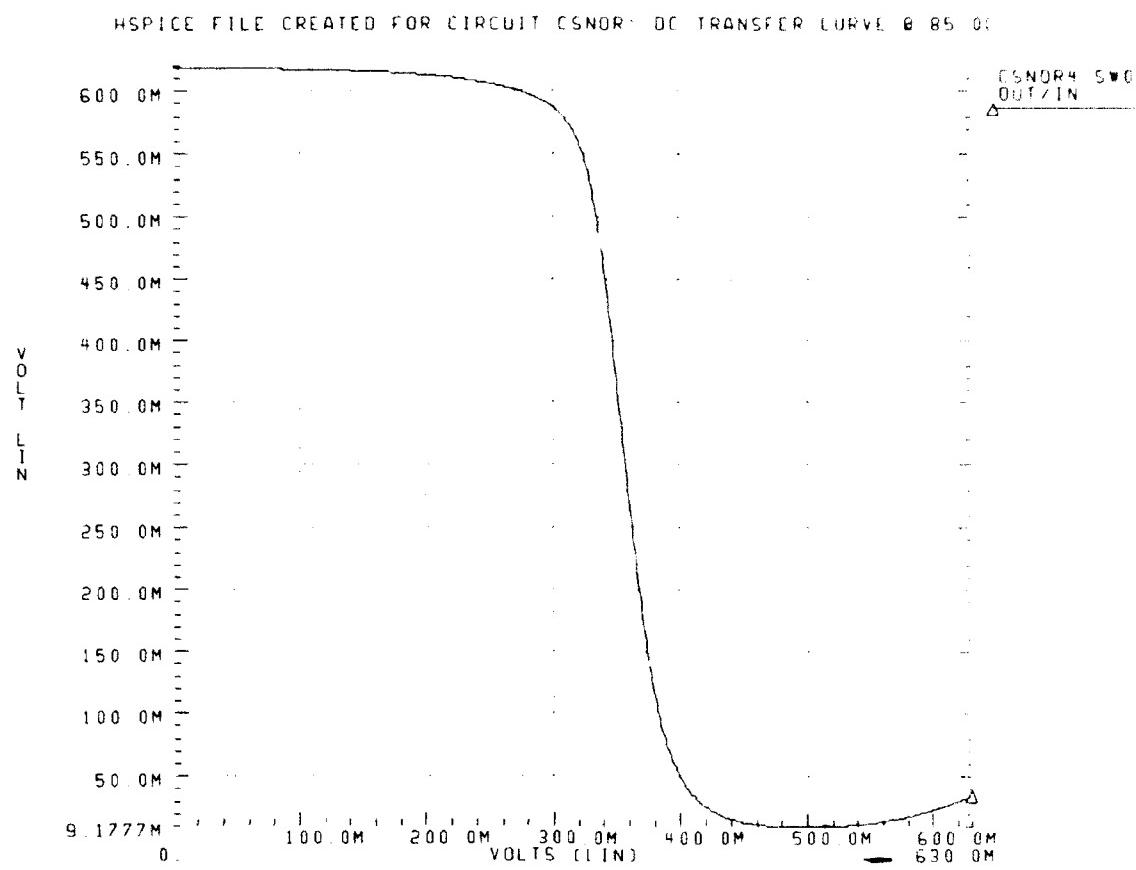


Figure 4.145 CSNOR DC Transfer Curve at 85.0C

C. GaAs DRAM Mixed DCFL-SBFL Logic Circuits

This section will present the specific mixed DCFL-SBFL gates used, presenting the schematic and logical equivalence for each. These gates are hybrids designed specifically for parameter requirements of particular circuits. The following characteristics for each circuit will be demonstrated and presented: transient analysis under standard load, power consumption at nominal and high temperature, propagation delays and noise margins. These characteristics will be further summarized in TABLE 4.1 on page 158. Germane comments will be made when appropriate.

1. DCFL-SBFL 2-input AND Gate (BS2AND)

The following graphs represent the operating characteristics of the BS2AND. This logic element was designed specifically for use in the DELAY circuit. See Figure 4.146 on page 137 for the BS2AND schematic and logical equivalence.

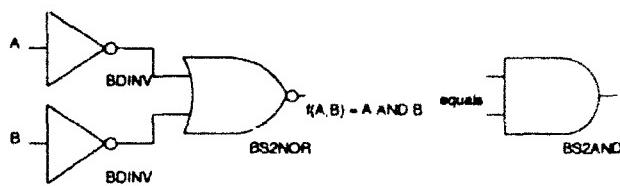


Figure 4.146 Schematic and Logical Equivalence for BS2AND

The transient analysis and power dissipation of the BS2AND operating at a temperature of 25.0C is shown in Figure 4.147 on page 137.

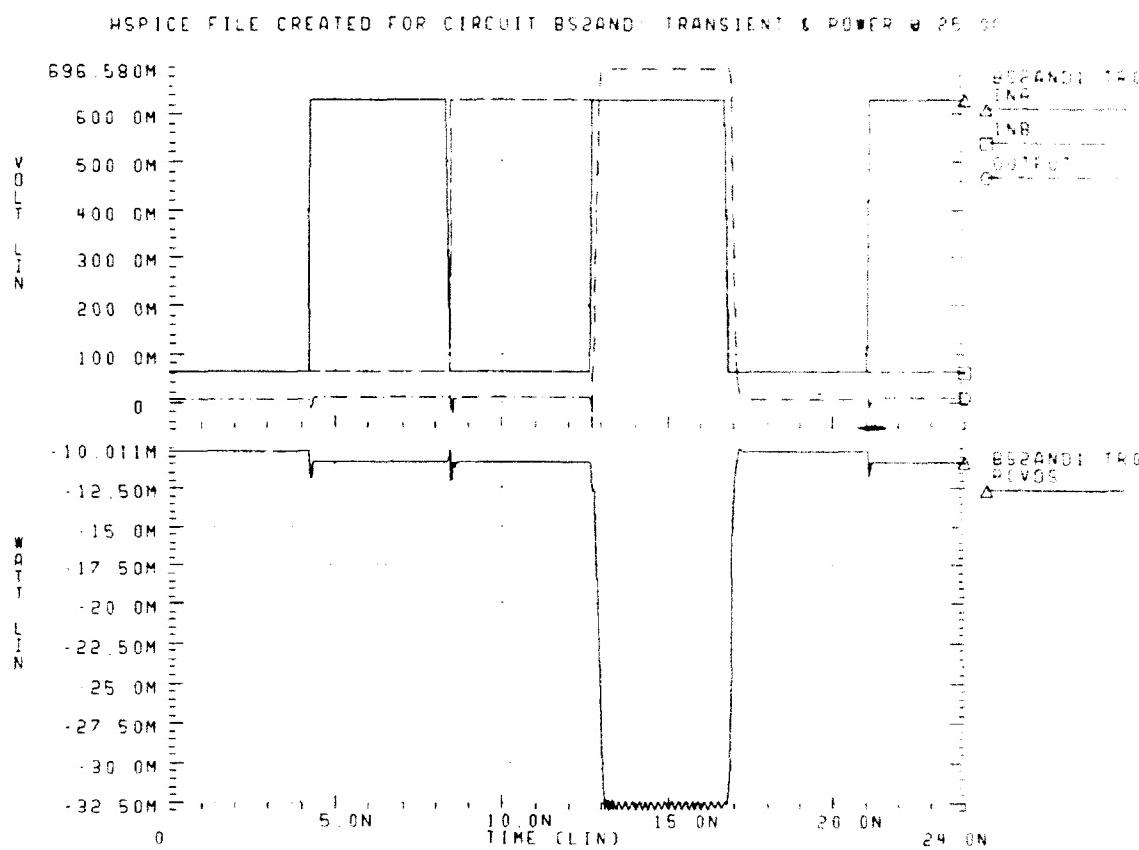


Figure 4.147 BS2AND HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the BS2AND operating at a temperature of 85.0C is shown in Figure 4.148 on page 138.

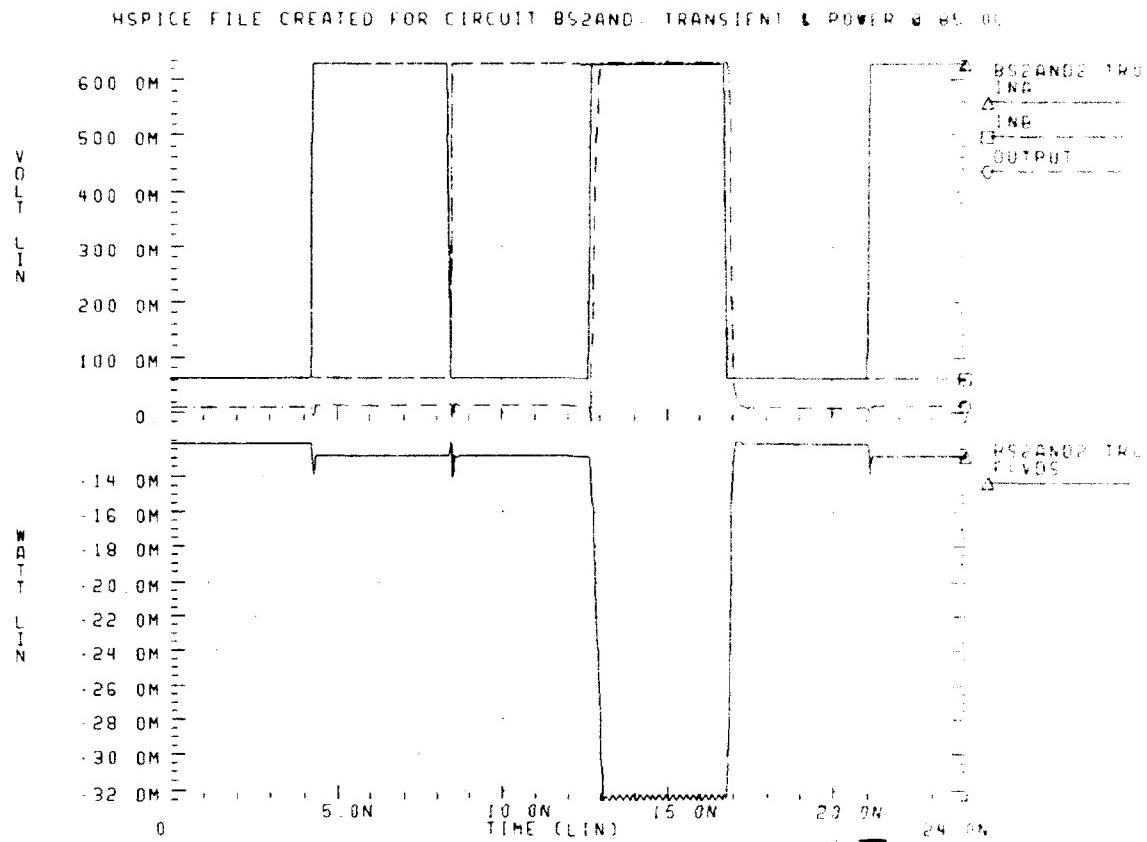


Figure 4.148 BS2AND HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the BS2AND logic gate operating at a temperature of 25.0C is shown in Figure 4.149 on page 139.

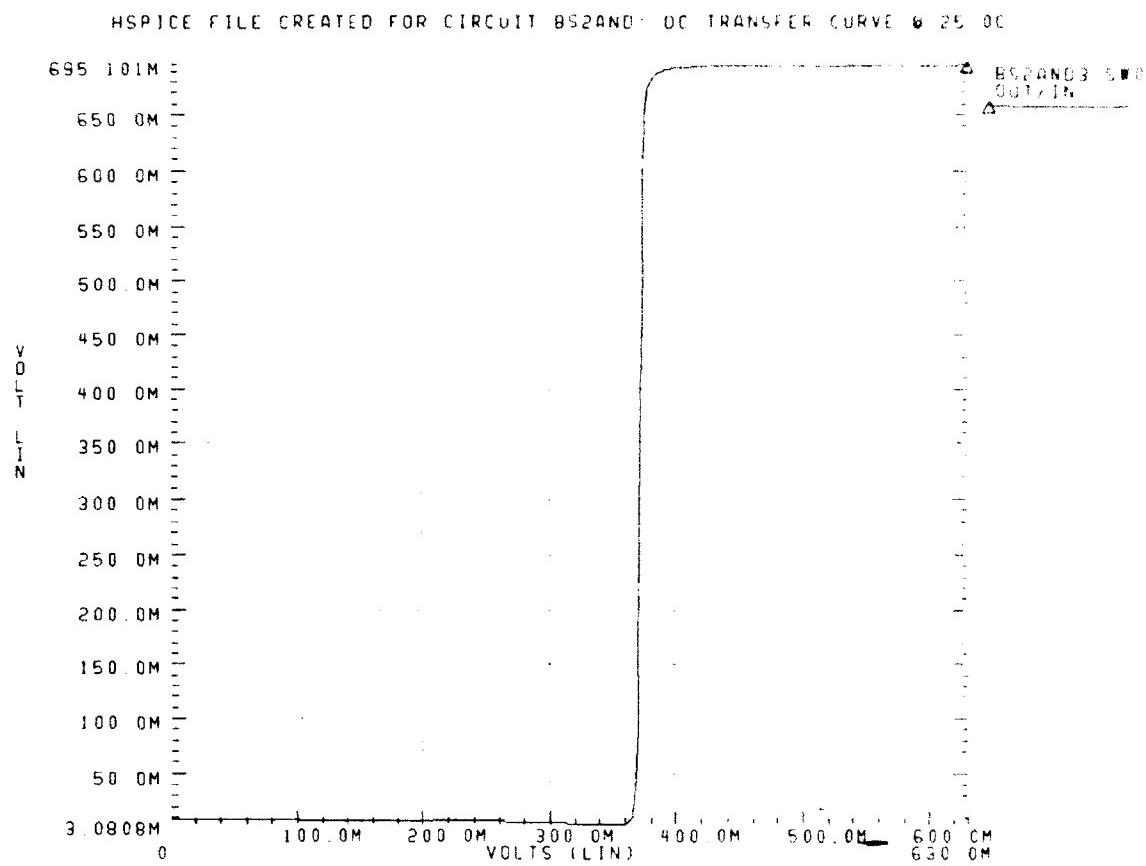


Figure 4.149 BS2AND DC Transfer Curve at 25.0C

The DC transfer characteristic of the BS2AND logic gate operating at a temperature of 85.0C is shown in Figure 4.150 on page 140.

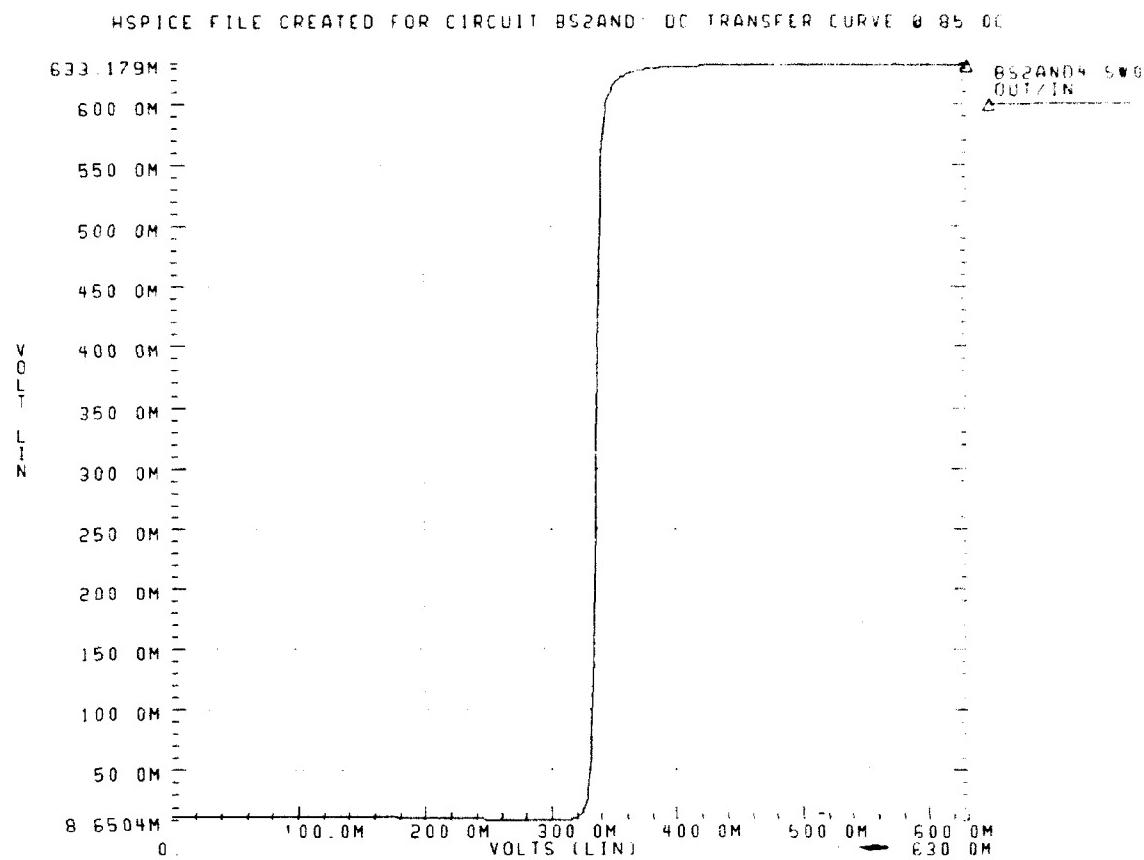


Figure 4.150 BS2AND DC Transfer Curve at 85.0C

2. SBFL-DCFL Data LATCH (SDLATCH)

The following graphs represent the operating characteristics of the SDLATCH. This logic element was designed specifically for use in the SDFF logic gate which is then used in the DREFRESH circuit. Notice that the structure of the logic element is such that it has a DCFL "front-end" with a SBFL "back-end" for use as drivers. See Figure 4.151 on page 141 for the SDLATCH schematic and logical equivalence.

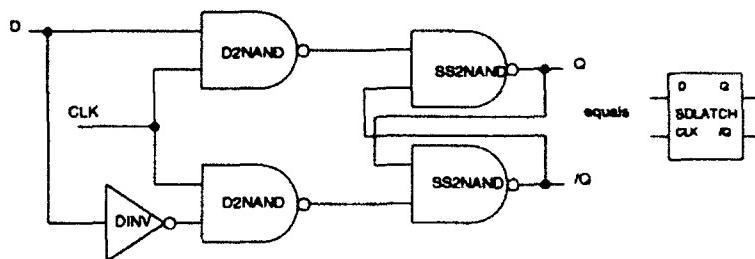


Figure 4.151 Schematic and Logical Equivalence for SDLATCH

The transient analysis and power dissipation of the SDLATCH operating at a temperature of 25.0C is shown in Figure 4.152 on page 142. Notice that in Figure 4.152 and Figure 4.153 on page 143, the lower (power) graph has several large power spikes. These spikes are caused by the surging of current when the Q output changes state which then in turn causes the /Q output to change state. Examining the schematic for the SDLATCH, as shown previously in Figure 4.151, one may see how this phenomenon occurs.

HSPICE FILE CREATED FOR CIRCUIT SDLATCH. TRANSIENT & POWER @ 25.0C

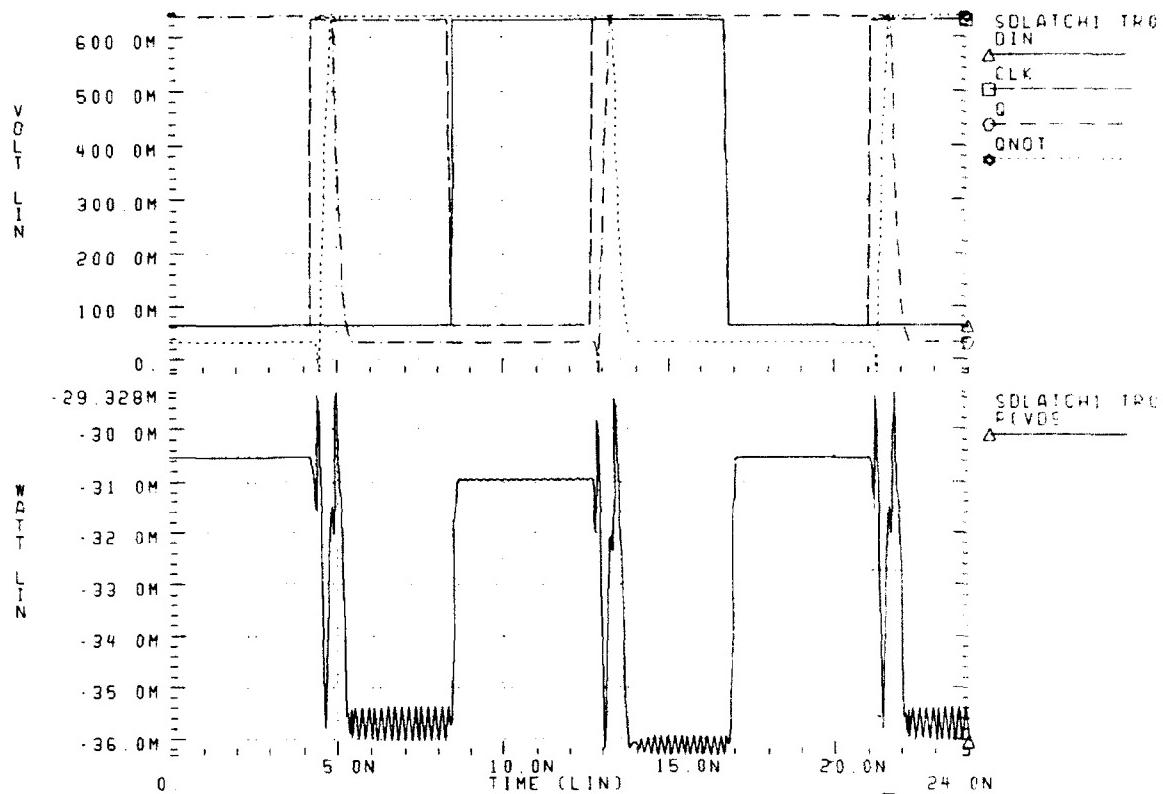


Figure 4.152 SDLATCH HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the SDLATCH operating at a temperature of 85.0C is shown in Figure 4.153 on page 143.

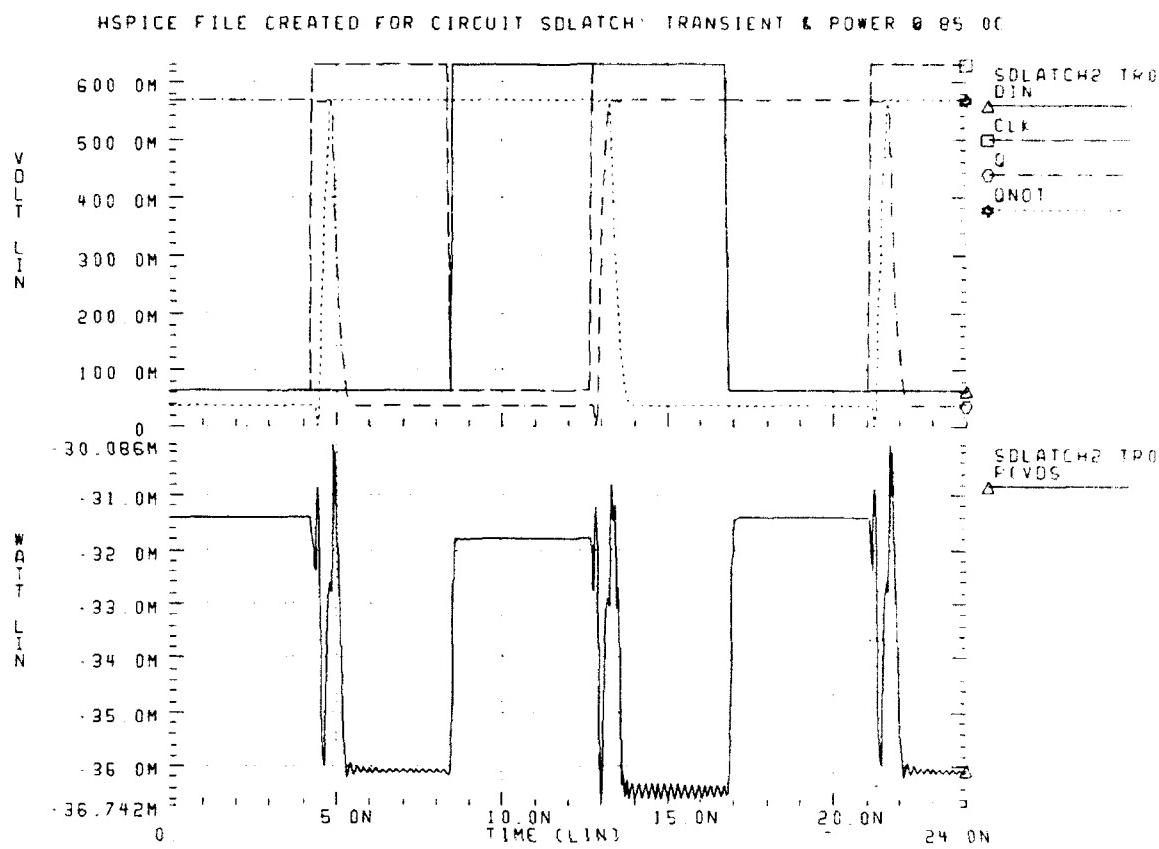


Figure 4.153 SDLATCH HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the SDLATCH logic gate operating at a temperature of 25.0C is shown in Figure 4.154 on page 144.

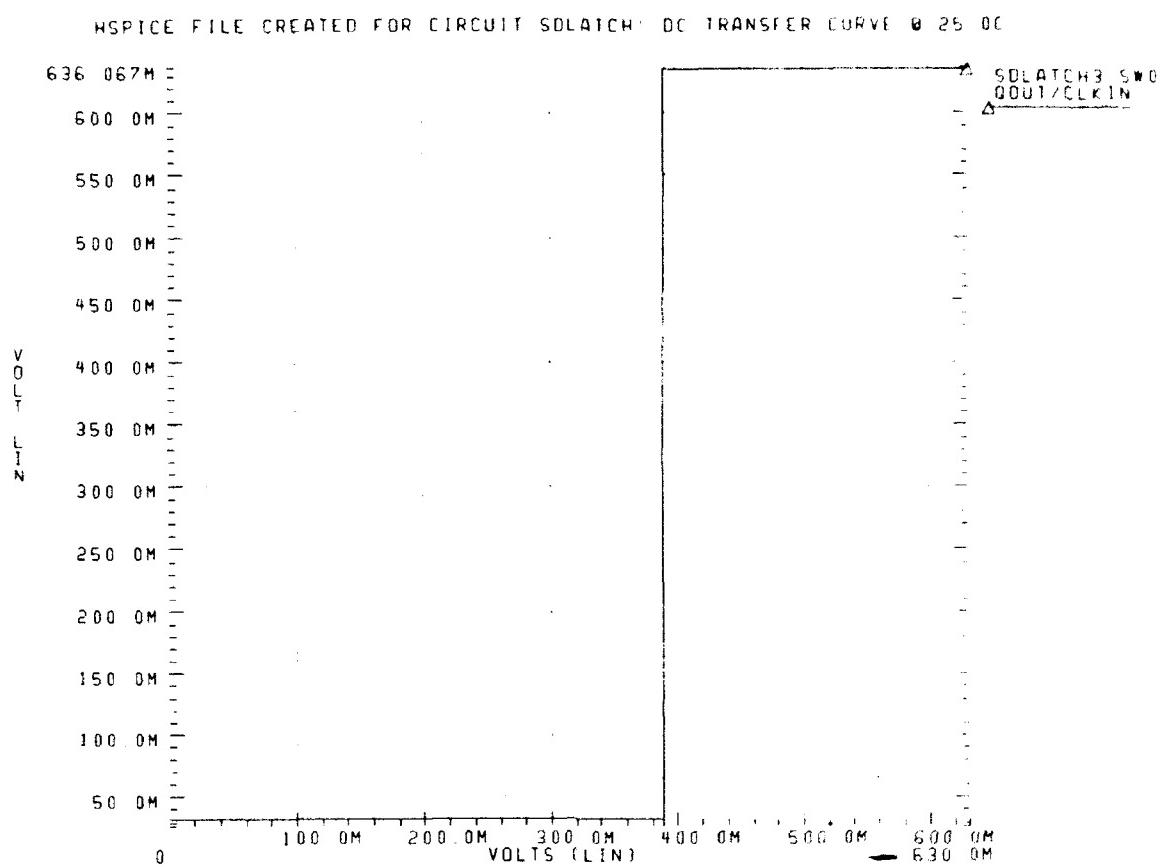


Figure 4.154 SDLATCH DC Transfer Curve at 25.0C

The DC transfer characteristic of the SDLATCH logic gate operating at a temperature of 85.0C is shown in Figure 4.150 on page 140.

HSPICE FILE CREATED FOR CIRCUIT SDLATCH1 DC TRANSFER CURVE @ 85.0C

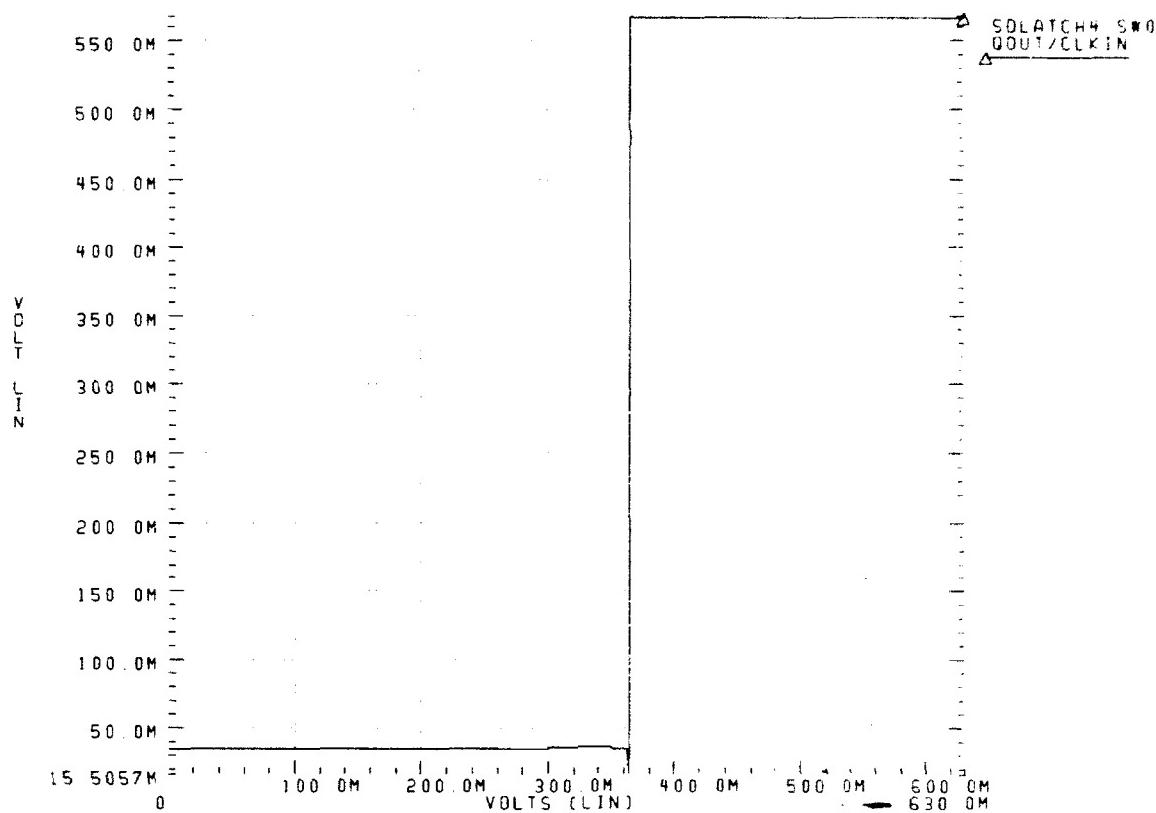


Figure 4.155 SDLATCH DC Transfer Curve at 85.0C

3. SBFL-DCFL Data Flip-Flop (SDFF)

The following graphs represent the operating characteristics of the SDFF. This logic element was designed specifically for use in the DREFRESH circuit. Notice that the structure of the logic element is such that it has a DCFL DLATCH "front-end" with a SBFL SDLATCH "back-end" for use as drivers. See Figure 4.156 on page 145 for the SDFF schematic and logical equivalence.

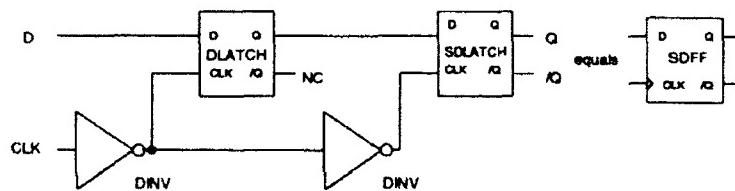


Figure 4.156 Schematic and Logical Equivalence for SDFF

The transient analysis and power dissipation of the SDFF operating at a temperature of 25.0C is shown in Figure 4.157 on page 146. The large power spikes, seen in Figure 4.157 and Figure 4.158 on page 147, arise from the use of the SDLATCH in the construction of the SDFF. Hence, the power spikes occur because of the current surges when the SDLATCH Q output changes state followed by the SDLATCH /Q output change of state.

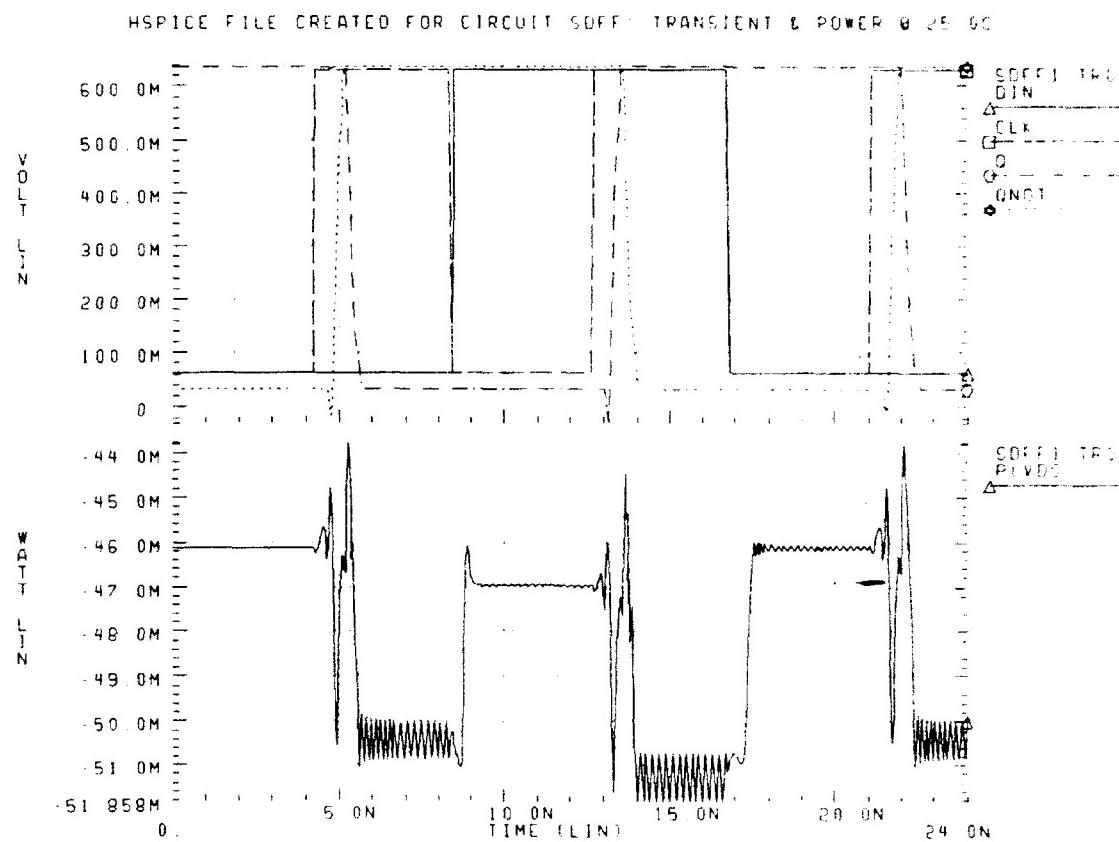


Figure 4.157 SDFF HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the SDFF operating at a temperature of 85.0C is shown in Figure 4.158 on page 147.

HSPICE FILE CREATED FOR CIRCUIT SDFF TRANSIENT & POWER @ 85.0C

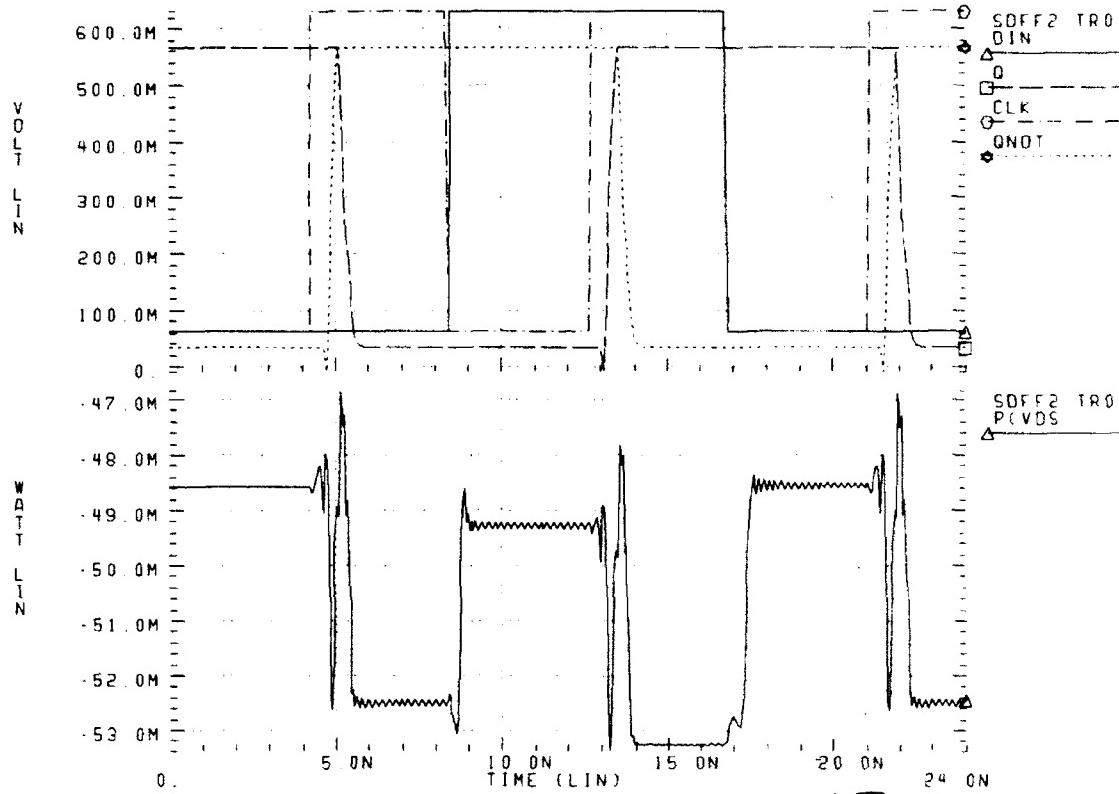


Figure 4.158 SDFF HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the SDFF logic gate operating at a temperature of 25.0C is shown in Figure 4.159 on page 148.

HSPICE FILE CREATED FOR CIRCUIT SDFF DC TRANSFER CURVE @ 25.0C

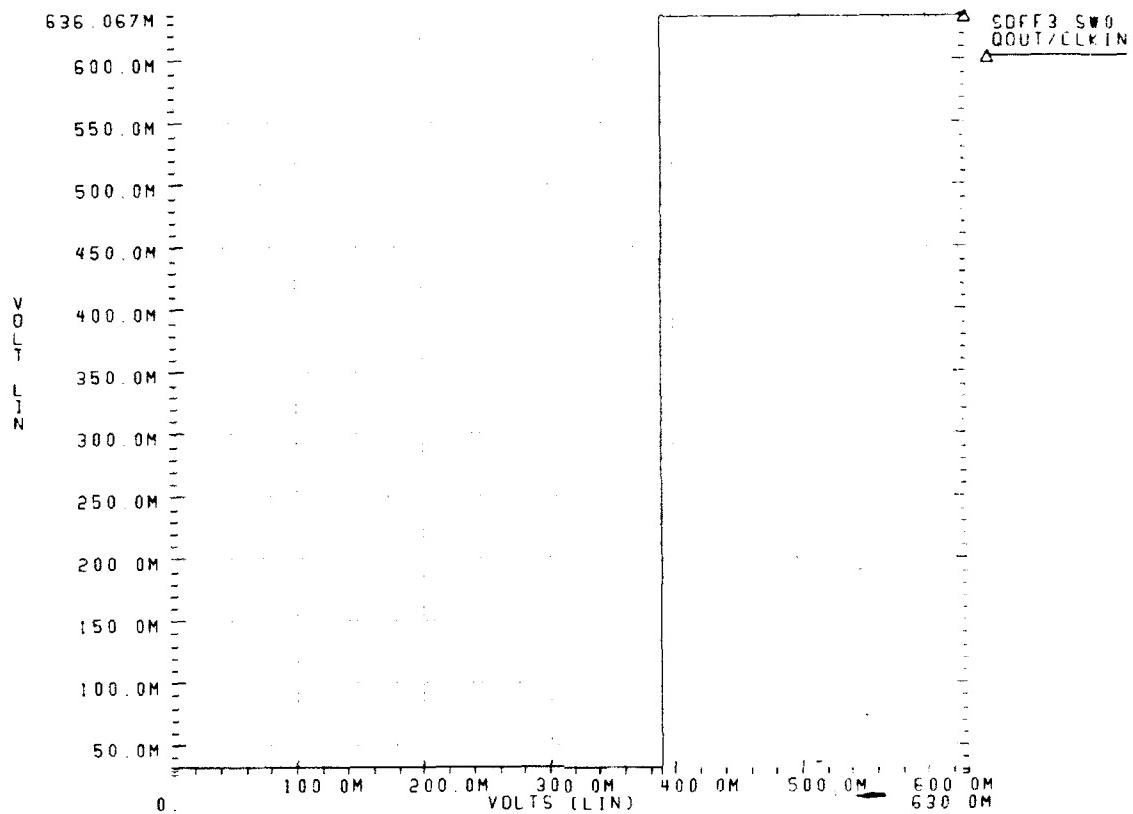


Figure 4.159 SDFF DC Transfer Curve at 25.0C

The DC transfer characteristic of the SDFF logic gate operating at a temperature of 85.0C is shown in Figure 4.160 on page 149.

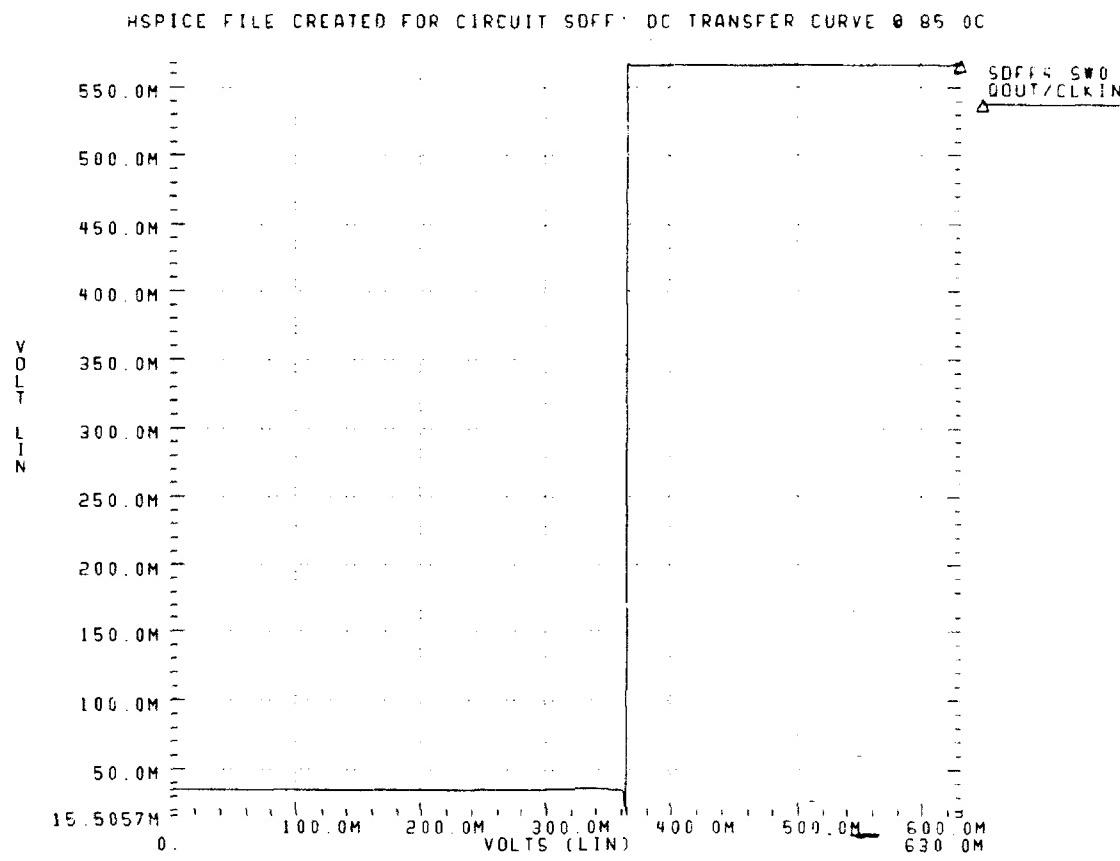


Figure 4.160 SDFF DC Transfer Curve at 85.0C

4. SBFL-DCFL DELAY Logic Element (DELAY)

The following graphs represent the operating characteristics of the DELAY. This logic element was designed specifically for use with the CLOCK circuit. The DELAY circuit will delay the input clock pulse by approximately 25% of a clock pulse width without applying logic inversion. See Table 4.1 for the specific details. See Figure 4.161 on page 149 for the DELAY schematic and logical equivalence.

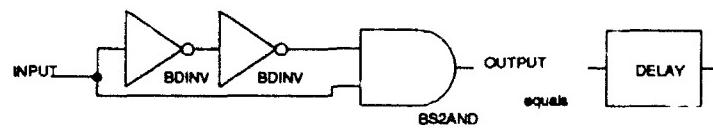


Figure 4.161 Schematic and Logical Equivalence for DELAY

The transient analysis and power dissipation of the DELAY operating at a temperature of 25.0C is shown in Figure 4.162 on page 150. It should be noted that this circuit was tested with a SBFL load of ten SINV's to better simulate real circuit loading conditions. See 'Listing File for DELAY Transient Analysis @ 25.0C" of Appendix A on page 283.

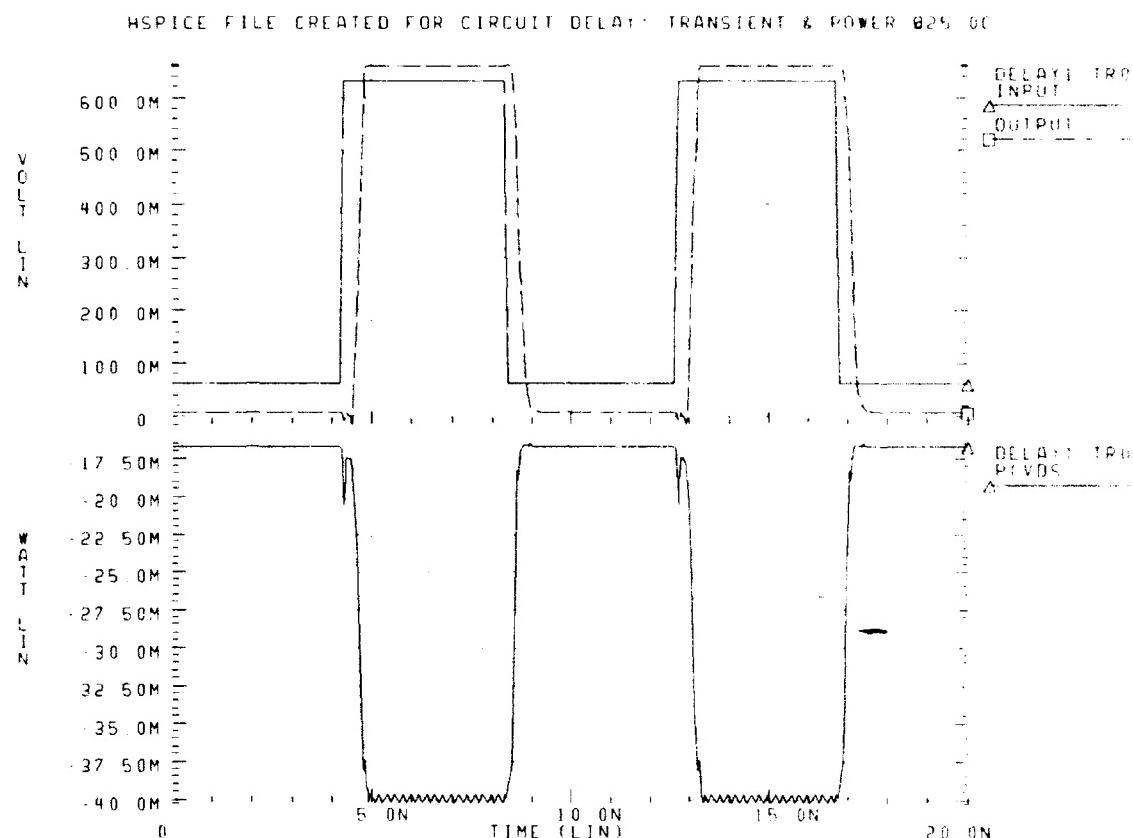


Figure 4.162 DELAY HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the DELAY operating at a temperature of 85.0C is shown in Figure 4.160 on page 149.

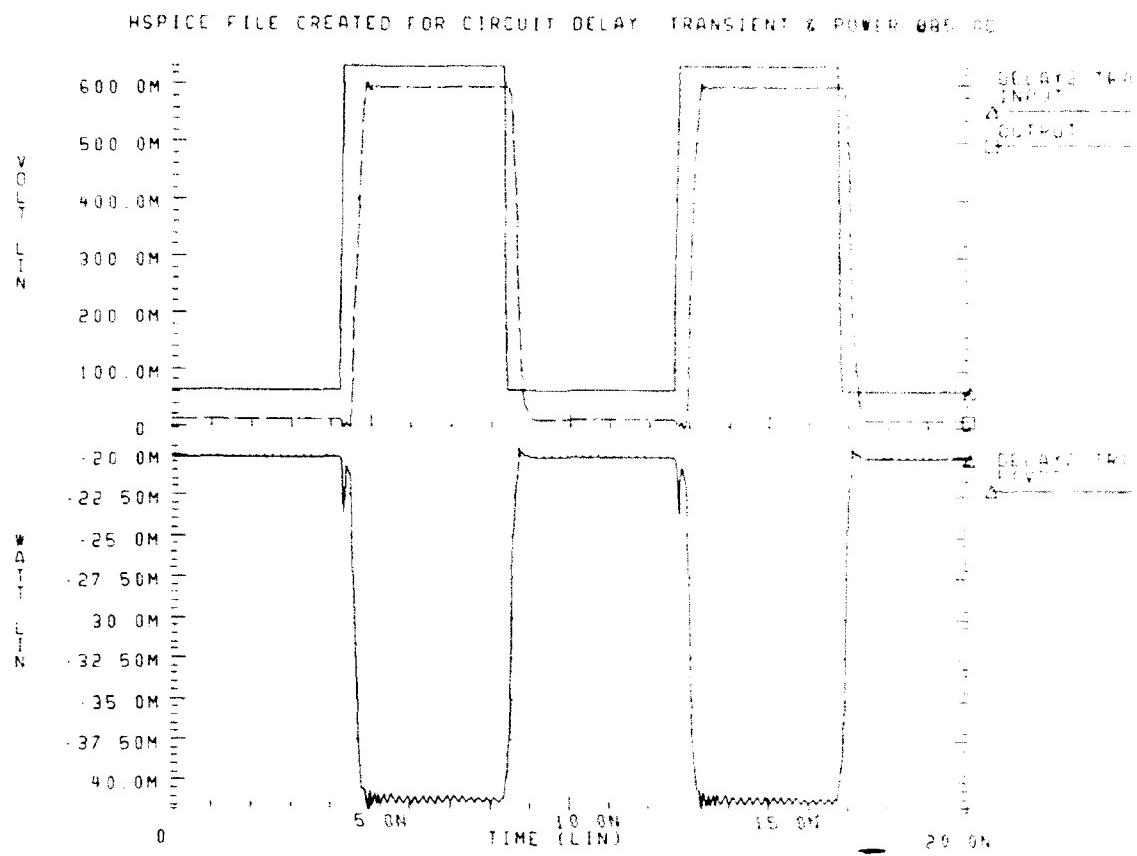


Figure 4.163 DELAY HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the DELAY logic gate operating at a temperature of 25.0C is shown in Figure 4.164 on page 152.

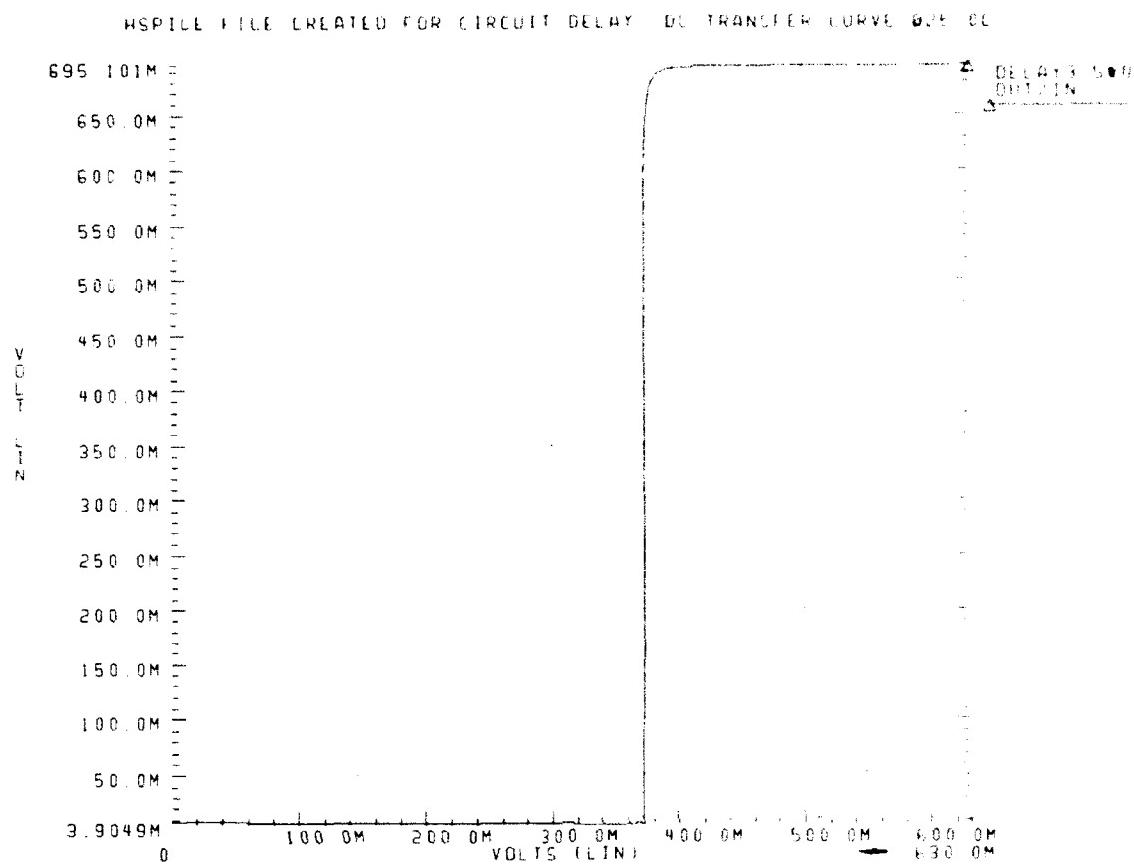


Figure 4.164 DELAY DC Transfer Curve at 25.0C

The DC transfer characteristic of the DELAY logic gate operating at a temperature of 85.0C is shown in Figure 4.165 on page 153.

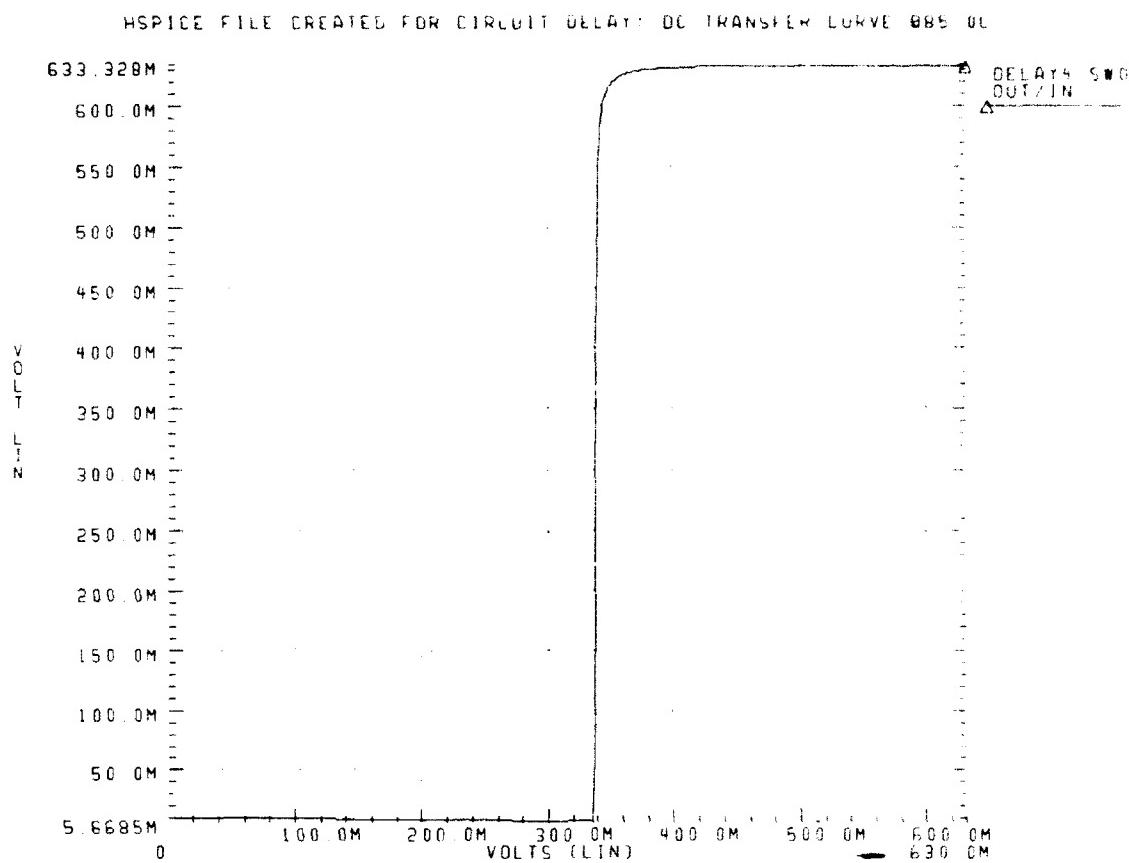
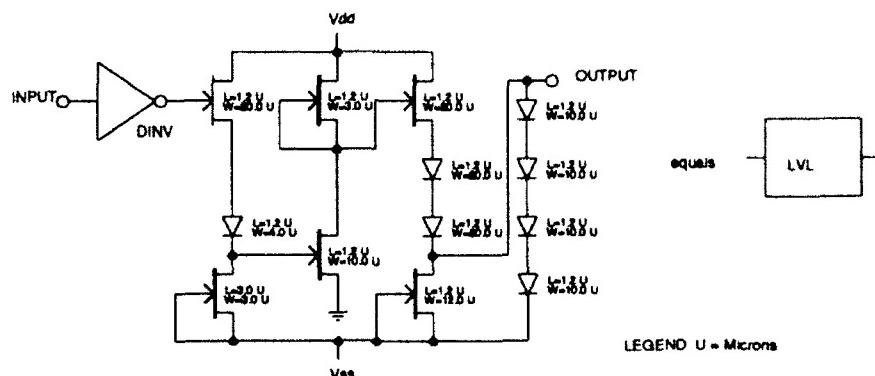


Figure 4.165 DELAY DC Transfer Curve at 85.0C

5. SBFL-DCFL Level Shifter Logic Element (LVL)

The following graphs represent the operating characteristics of the LVL. The GaAs DRAM memory array uses d-mode MESFETs as the access switches for the charge storage parallel plate capacitors. In order to directly control the d-mode MESFET transistors, a voltage level shifter is required to accept an input voltage of 0.00V to 0.63V and shifts it down to -1.20V to 0.00V. This level shifting circuit is by design an inverting circuit, thus, the DINV on its input. The diodes shown are actually GaAs e-mode MESFETs with the drain and source connected, which is referred to as "back-connected". See Figure 4.166 on page 154 for the LVL schematic and logical equivalence.



Note 1: The DINV on the INPUT inverts the incoming signal as the LVL circuit itself is inverting.
 Note 2: INPUT Voltage= 0.00 > 0.85V, OUTPUT Voltage= -1.00V > -0.00V
 Note 3: The devices are actually GaAs E MESFETs backconnected, i.e., drain and source connected.

Figure 4.166 Schematic and Logical Equivalence for LVL

The transient analysis and power dissipation of the LVL operating at a temperature of 25.0C is shown in Figure 4.167 on page 155. This is the first circuit encountered that utilized a second power supply, V_{SS} . The power dissipation by both power supplies is shown in the lower graph of the indicated figure. It should be noted that this circuit was tested with a load of ten d-mode MESFETs to better simulate real circuit loading conditions. See "Listing File for LVL Transient Analysis @ 25.0C" of Appendix A on page 287.

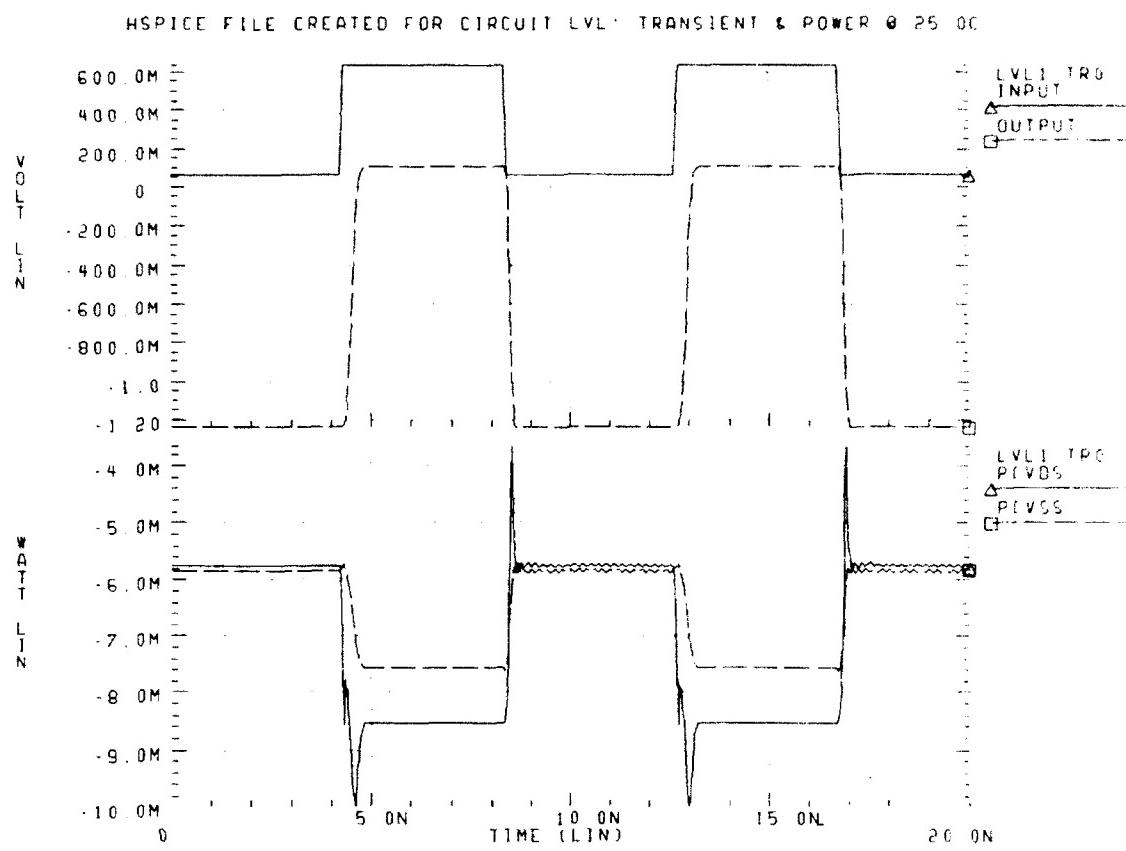


Figure 4.167 LVL HSPICE Transient Analysis and Power Dissipation at 25.0C

The transient analysis and power dissipation of the LVL operating at a temperature of 85.0C is shown in Figure 4.168 on page 156.

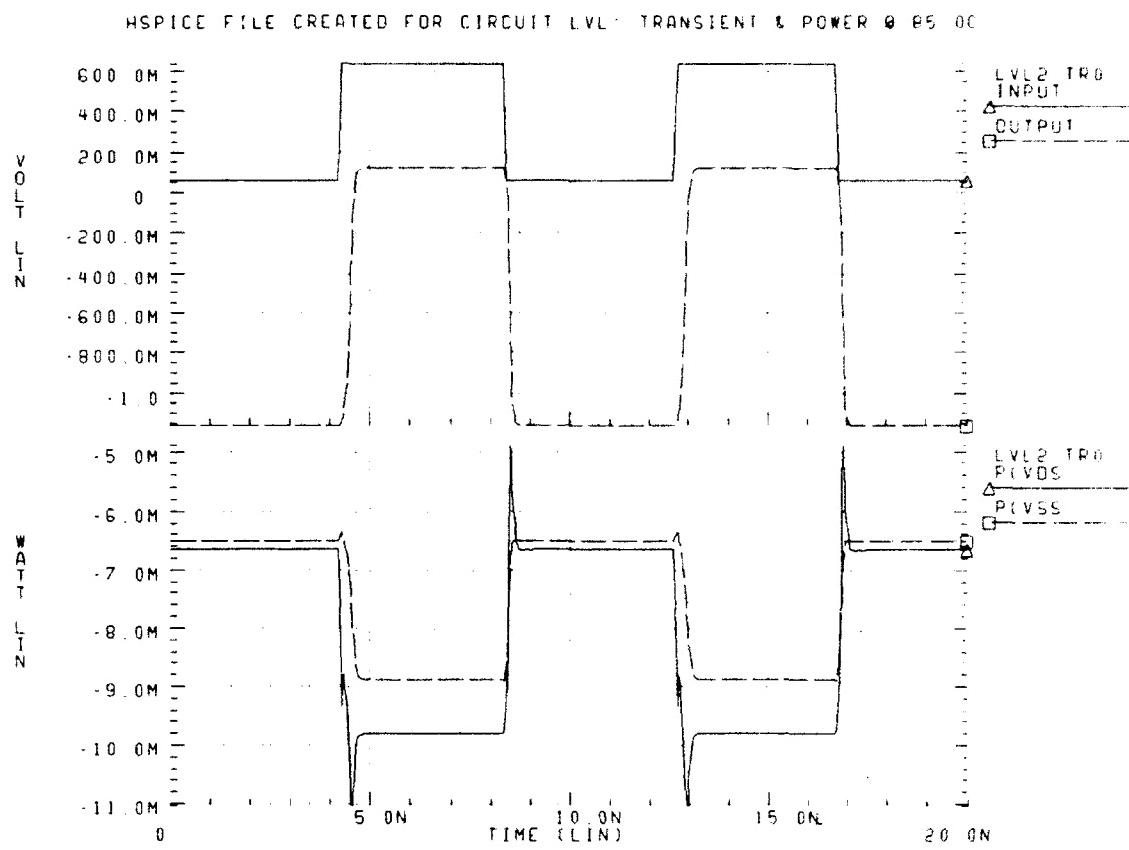


Figure 4.168 LVL HSPICE Transient Analysis and Power Dissipation at 85.0C

The DC transfer characteristic of the LVL logic gate operating at a temperature of 25.0C is shown in Figure 4.169 on page 157.

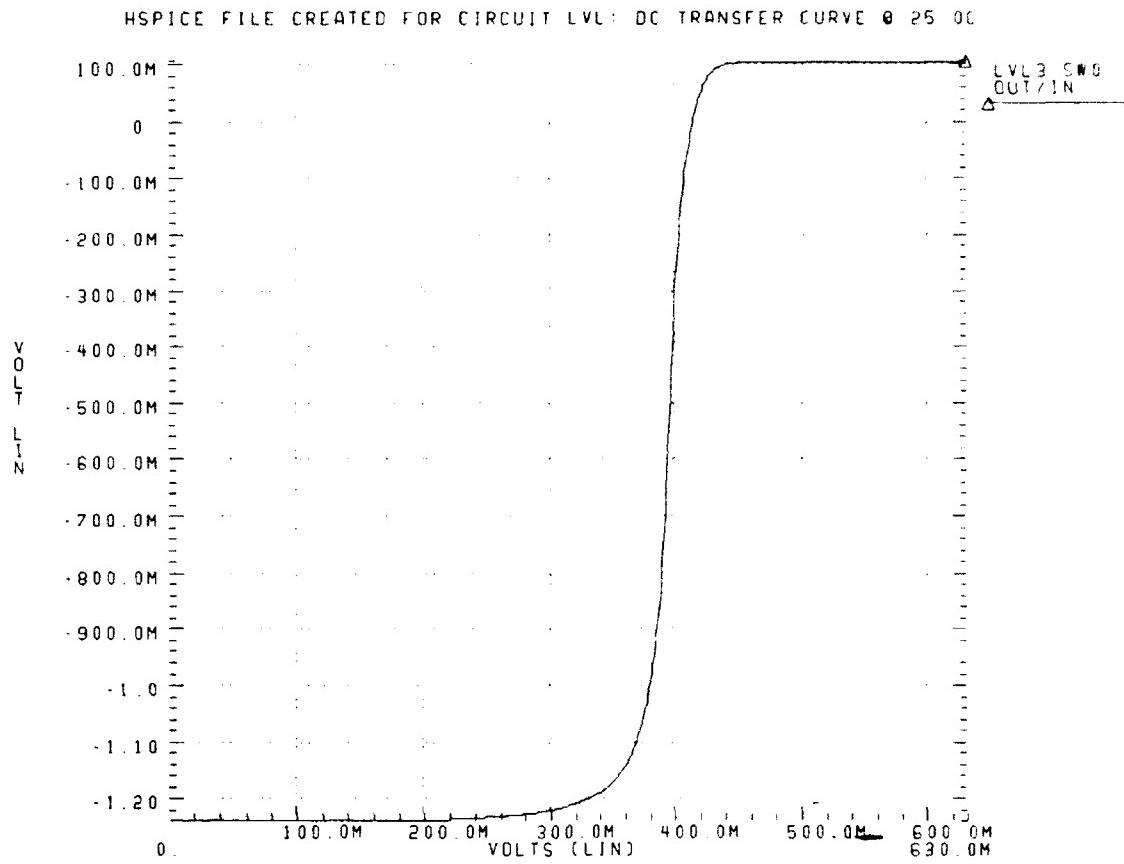


Figure 4.169 LVL1 DC Transfer Curve at 25.0C

The DC transfer characteristic of the LVL logic gate operating at a temperature of 85.0C is shown in Figure 4.170 on page 158.

Noise margins for the level shifter circuitry will not be discussed (or listed in TABLE 4.1) as level shifting circuitry provides no useful logic function and because level shifter circuitry usually has a linear transfer characteristic.

HSPICE FILE CREATED FOR CIRCUIT LVL DC TRANSFER CURVE @ 85.0C

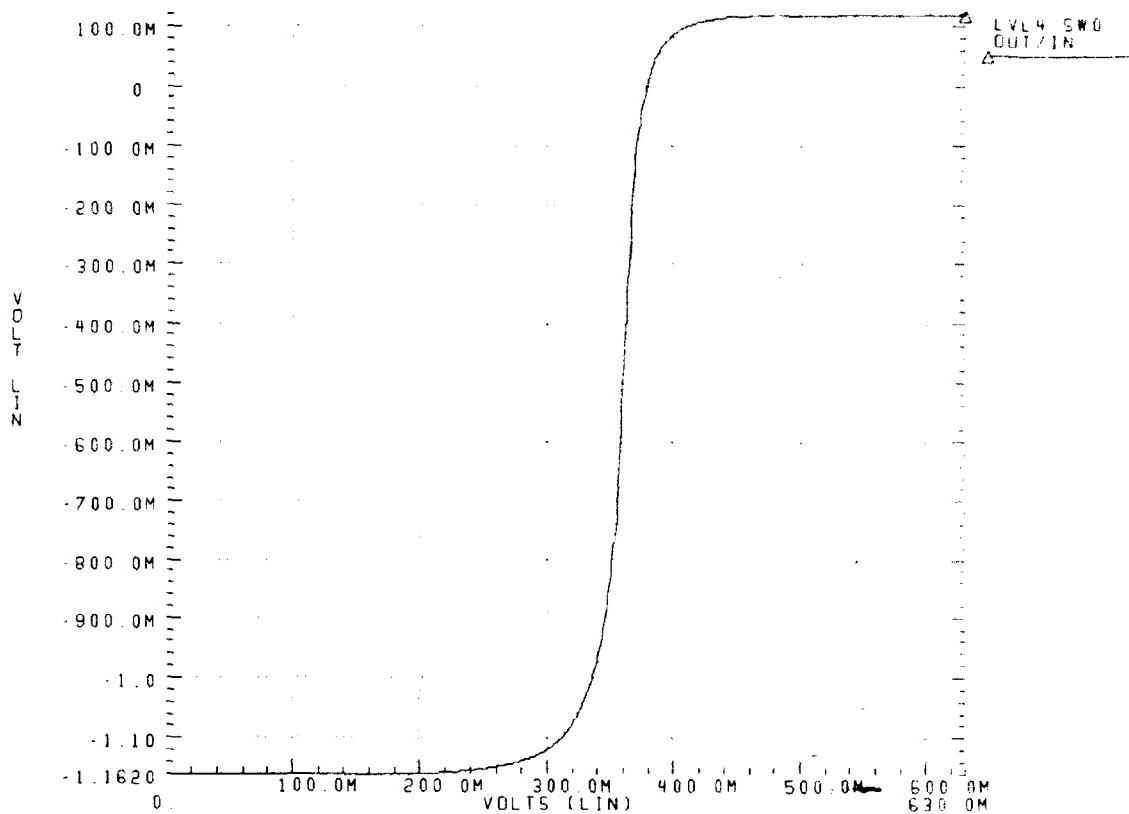


Figure 4.170 LVL DC Transfer Curve at 85.0C

D. SUMMARY

This concludes the detailed analysis of the GaAs DRAM fundamental logic elements and circuits. The characteristics of each of this circuits is found in TABLE 4.1. The next chapter will begin discussion of the major circuits of the GaAs DRAM.

TABLE 4.1 GaAs DRAM LOW-LEVEL CIRCUIT OPERATING CHARACTERISTICS

Circuit Name	t_{PHL} (ps)	t_{PLH} (ps)	t_{RISE} (ps)	t_{FALL} (ps)	t_{DELAY} (ps)	NM_L (V)	NM_H (V)
DINV @25.0C	108	71	352	130	63	0.260	0.085

TABLE 4.1 GaAs DRAM LOW-LEVEL CIRCUIT OPERATING CHARACTERISTICS

Circuit Name	t_{PHL} (ps)	t_{PLH} (ps)	t_{RISE} (ps)	t_{FALL} (ps)	t_{DELAY} (ps)	NM_L (V)	NM_H (V)
DINV @85.0C	112	58	312	146	77	0.205	0.040
D2NOR @25.0C	69	112	379	172	95	0.260	0.070
D2NOR @25.0C	65	108	347	157	117	0.205	0.065
D3NOR @25.0C	68	158	426	239	127	0.240	0.083
D3NOR @85.0C	64	148	366	240	148	0.220	0.045
D4NOR @25.0C	61	220	456	202	159	0.260	0.070
D4NOR @85.0C	58	204	399	148	187	0.210	0.060
D2NAND @25.0C	76	174	384	256	138	0.230	0.120
D2NAND @85.0C	78	146	355	402	148	0.175	0.095
DD2NAND @25.0C	92	130	383	103	123	0.330	0.205
DD2NAND @25.0C	207	149	337	121	141	0.360	0.210
DD2NAND @85.0C	209	129	304	138	150	0.310	0.180
DD3NAND @25.0C	254	139	337	135	133	0.360	0.205
DD3NAND @85.0C	254	124	305	168	145	0.305	0.180
DD2AND @85.0C	84	126	350	98	133	0.275	0.160
DD3AND @25.0C	82	145	397	88	130	0.370	0.220
DD3AND @85.0C	73	140	394	103	146	0.365	0.225

TABLE 4.1 GaAs DRAM LOW-LEVEL CIRCUIT OPERATING CHARACTERISTICS

Circuit Name	t_{PHL} (ps)	t_{PLH} (ps)	t_{RISE} (ps)	t_{FALL} (ps)	t_{DELAY} (ps)	NM_L (V)	NM_H (V)
DD4AND @25.0C	76	159	418	101	139	0.360	0.225
DD4AND @85.0	66	153	416	102	160	0.325	0.190
DD2OR @25.0C	176	118	342	137	114	0.365	0.230
DD2OR @85.0C	176	111	325	156	122	0.315	0.220
DD3OR @25.0C	222	120	350	138	116	0.370	0.225
DD3OR @85.0C	221	112	369	166	123	0.300	0.210
DD4OR @25.0C	258	122	351	169	118	0.365	0.225
DD4OR @85.0C	262	132	370	203	124	0.300	0.220
BDINV @25.0C	42	95	290	68	78	0.240	0.150
BDINV @85.0C	48	71	247	64	78	0.190	0.115
DLATCH @25.0C	610	221	534	380	617	0.340	0.225
DLATCH @85.0C	631	209	512	456	595	0.295	0.190
CPDFF @25.0C	930	445	419	194	933	0.370	0.190
CPDFF @85.0C	900	425	379	216	875	0.320	0.150
SINV @25.0C	110	140	267	377	111	0.340	0.170
SINV @85.0C	103	122	261	349	122	0.290	0.130
SSINV @25.0C	18	93	123	51	56	0.320	0.270

TABLE 4.1 GaAs DRAM LOW-LEVEL CIRCUIT OPERATING CHARACTERISTICS

Circuit Name	t_{PHL} (ps)	t_{PLH} (ps)	t_{RISE} (ps)	t_{FALL} (ps)	t_{DELAY} (ps)	NM_L (V)	NM_H (V)
SSINV @85.0C	24	80	121	52	56	0.270	0.245
S2NOR @25.0C	95	231	303	632	180	0.330	0.170
S2NOR @85.0C	92	206	300	443	192	0.280	0.130
S3NOR @25.0C	79	309	367	366	228	0.325	0.165
S3NOR @85.0C	80	280	358	307	242	0.275	0.130
S4NOR @25.0C	75	371	407	383	276	0.320	0.175
S4NOR @85.0C	76	340	417	311	294	0.260	0.135
S3OR @25.0C	359	192	256	415	181	0.380	0.270
S3OR @85.0C	346	178	256	406	178	0.330	0.250
SS2NAND @25.0C	295	298	266	571	261	0.330	0.165
SS2NAND @85.0C	291	259	257	398	254	0.280	0.135
SS4NAND @25.0C	376	289	264	275	251	0.355	0.245
SS4NAND @85.0C	371	252	259	329	242	0.315	0.190
SS3AND @25.0C	153	258	323	305	235	0.375	0.245
SS3AND @85.0C	137	238	313	183	236	0.320	0.245
SS4AND @25.0C	145	286	353	255	262	0.375	0.260
SS4AND @85.0C	131	271	360	105	269	0.335	0.230

TABLE 4.1 GaAs DRAM LOW-LEVEL CIRCUIT OPERATING CHARACTERISTICS

Circuit Name	t _{PHL} (ps)	t _{PLH} (ps)	t _{RISE} (ps)	t _{FALL} (ps)	t _{DELAY} (ps)	NM _L (V)	NM _H (V)
BS2NOR @25.0C	17	229	229	65	157	0.320	0.230
BS2NOR @85.0C	25	202	214	58	159	0.260	0.195
CSINV @25.0C	24	119	160	59	79	0.330	0.240
CSINV @85.0C	30	101	154	60	78	0.280	0.210
CSNOR @25.0C	27	194	202	87	138	0.325	0.200
CSNOR @85.0C	35	170	194	73	140	0.275	0.175
BS2AND @25.0C	244	202	219	343	183	0.375	0.325
BS2AND @85.0C	199	181	198	188	172	0.340	0.300
SDLATCH @25.0C	797	370	289	490	828	0.360	0.245
SDLATCH @85.0C	773	348	281	419	774	0.330	0.205
SDFF @25.0C	1100	676	292	305	1132	0.360	0.240
SDFF @85.0C	1047	623	289	344	1051	0.325	0.210
DELAY @25.0C	431	346	255	301	415	0.375	0.320
DELAY @85.0C	387	286	259	287	381	0.355	0.285
LVL @25.0C	299	120	514	247	293	N/A	N/A
LVL @85.0C	266	115	435	294	249	N/A	N/A

V. GALLIUM ARSENIDE DRAM HIGH-LEVEL CIRCUITS

This chapter will discuss in some detail the major blocks of the highest level block diagram, see Figure 6.1 on page 218. The major circuits to be discussed in this chapter include CLOCK, DECODER, DECODDRVER, DREFRESH, WRITEP, COUNTER, OUTPUT, WLOGIC, and chip pad drivers/receivers. The GaAs DRAM memory array will be mentioned briefly and only in block diagram form (as it was the cornerstone of the work by Vagts [Ref. 8]). Each major block of the block diagram will have its own block diagram, transient analysis, power dissipation and general comments. A summary of the important circuit characteristics may be found in TABLE 5.1 on page 216.

A. Two-Phase Non-Overlapping Clock (CLOCK)

In order to operate any synchronous digital circuit, a clock of some sort is necessary. The GaAs DRAM circuit is no exception. The original form of the clock arose from the signals required to provide necessary timing for the GaAs DRAM memory array. This further lead to the creation and adaptation of the LVL and DELAY circuits. As utilized in the GaAs DRAM, this CLOCK circuit accepts a single input 50% duty cycle digital square wave of 0.06V to 0.63V and provides in outputs: phase one (PH1), phase one level shifted (PH1L), phase two (PH2), phase two delayed (PH2D), and phase two level shifted and delayed (PH2LD). The circuit requires two power supplies, V_{DD} and V_{SS} , where V_{SS} is used only for the level shifting circuitry. This circuit is one of the most tested and adjusted of all the circuits in the GaAs DRAM support circuitry as the fanout of the CLOCK is very large and clock skew under operational load was a serious concern. The power dissipation or consumption of this circuit is enormous, but, it was believed to be necessary to prevent other more serious timing anomalies. See Figure 5.1 on page 164 for a schematic and block diagram of the CLOCK circuit.

The CLOCK circuit was simulated using output loads of ten SBFL inverters and ten depletion mode MESFETs as loads for the level shifted clock outputs of PH1L and PH2LD. The simulation was executed twice, once at a nominal temperature of 25.0C and once at a nominal temperature of 85.0C. Power dissipation of these major circuits is certainly an issue and so the second (lower) (generally) graph on each will indicate the power dissipation of the circuit under test. The transient analysis and power dissipation of the CLOCK operating at a temperature of 25.0C is shown in Figure 5.2 on page 165. See "Listing File for CLOCK

Transient Analysis @ 25.0C" of Appendix A on page 290. The transient analysis and power dissipation of the CLOCK operating at a temperature of 85.0C is shown in Figure 5.3 on page 166. See TABLE 5.1 on page 216 for a summary of the CLOCK circuit operating characteristics.

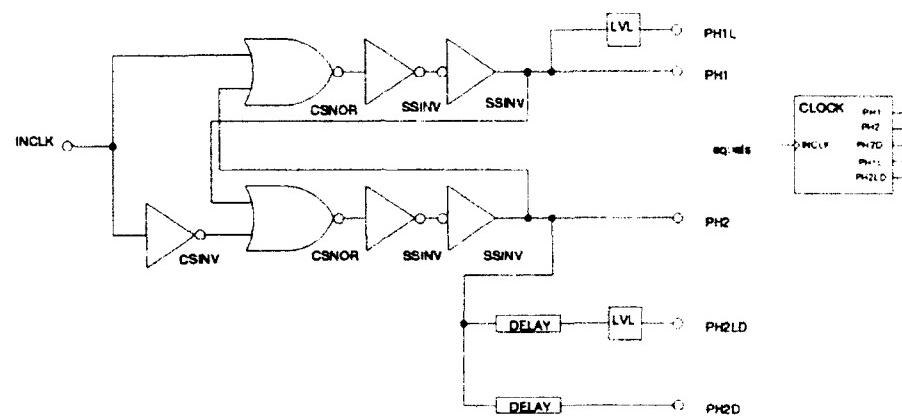


Figure 5.1 Schematic and Logical Equivalence for CLOCK

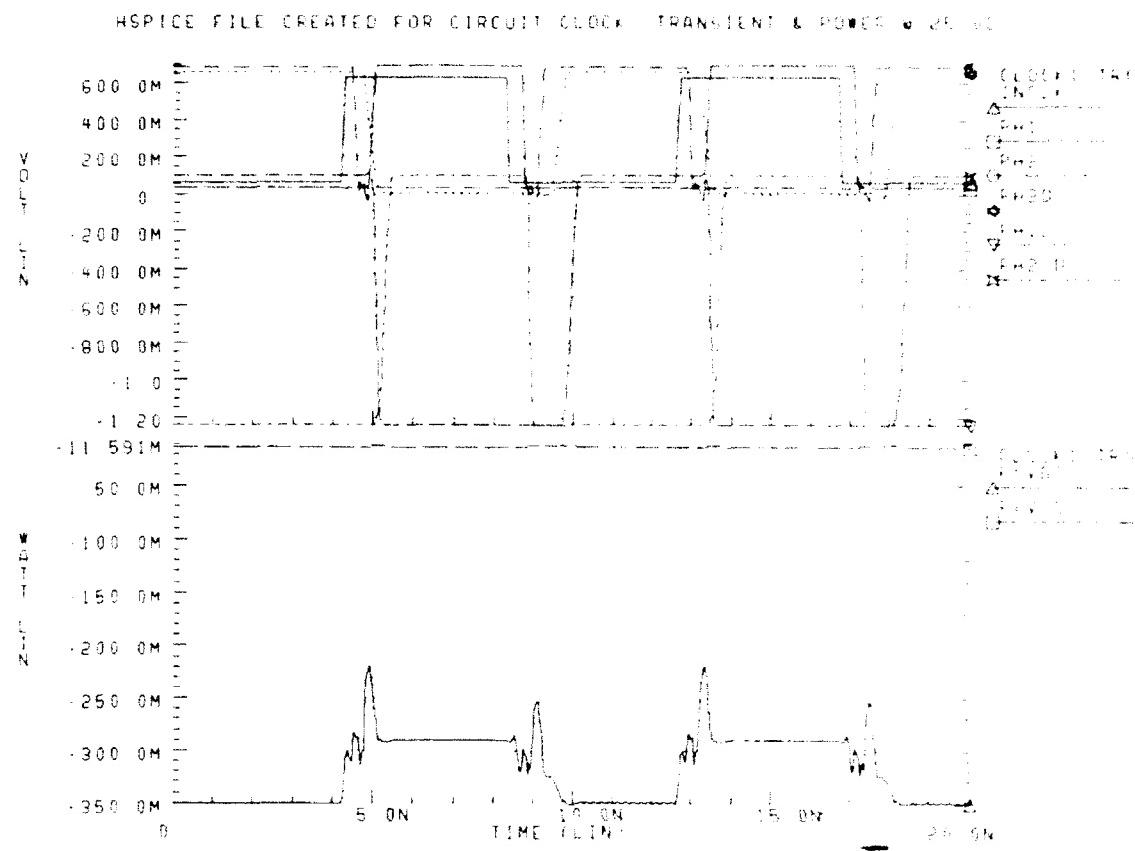


Figure 5.2 CLOCK HSPICE Transient Analysis and Power Dissipation at 25.0C

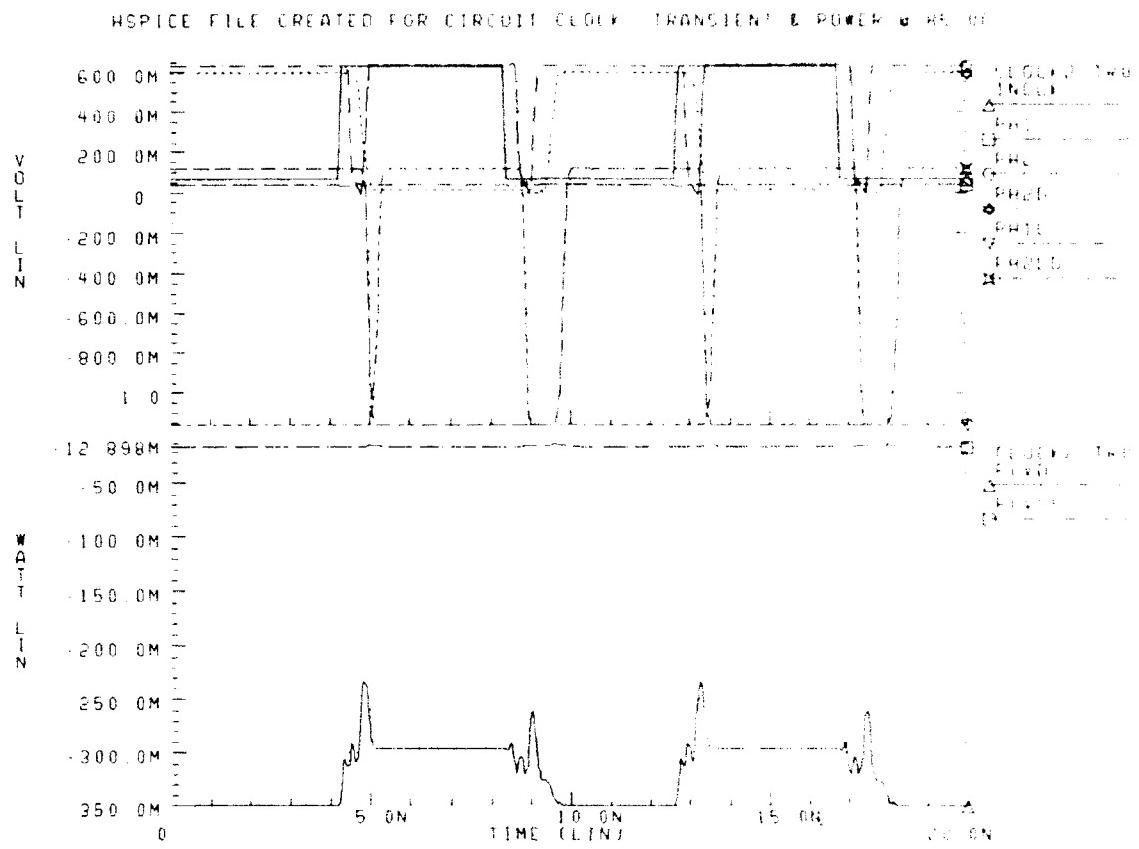


Figure 5.3 CLOCK HSPICE Transient Analysis and Power Dissipation at 85.0C

B. One-of-Eight Decoder (DECODER)

As this design is the support circuitry for an eight address by four data bit memory array, it was necessary to construct a decoder which would accept the three input address lines and decode these to one-of-eight memory array address line. The circuit DECODER is a non-clocked, non-latched glue logic decoder. It has six inputs (active HIGH), the three address lines and three enable lines, and nine outputs (active HIGH). The eight (one-of-eight) address lines and the enable line is carried through, being the OR of the three input enable lines. The DECODER circuit was constructed specially for use in a larger circuit, DECODDRVR, which will be discussed later.

As a note, the initial DECODER design used data latches. The idea behind this was to latch the three input address lines while the decode operation occurred. It was found that the throughput of the circuit suffered to such an extent that the data latches were removed. The long data latch activation times were the reason for the degradation of the DECODER throughput, see TABLE 4.1 on page 158.

The DECODER schematic and logical representation are shown in Figure 5.4 on page 167. It can be seen in Figure 5.4 on page 167 that the ENBL signals are logically ORed such that any of the three will enable the outputs of the four-input AND gates. Notice also that the entire circuit operates using active HIGH logic, not the case in the standard transistor-transistor-logic (TTL) 74138. Ease of design dictated the use of active HIGH inputs and outputs.

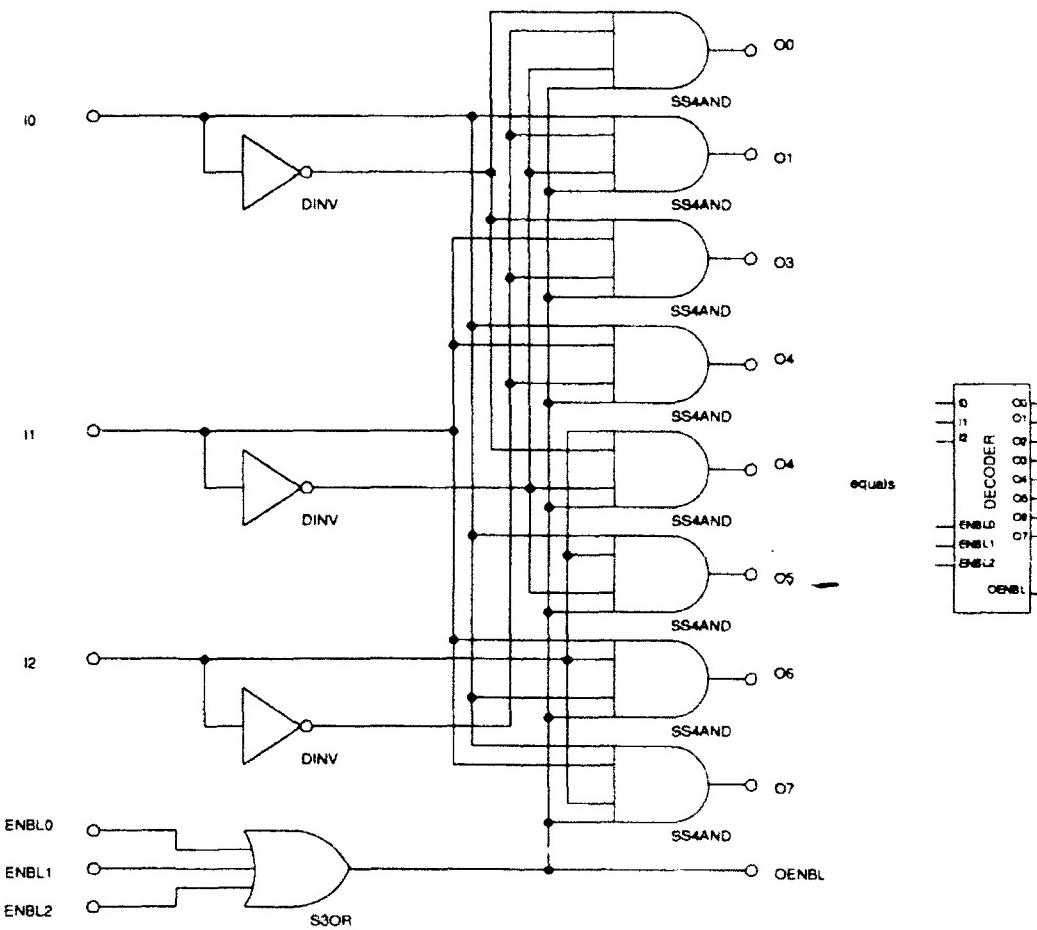


Figure 5.4 DECODER Schematic and Logical Equivalence

The transient analysis of the DECODER circuit is shown in two parts. (Additionally, the simulation was executed at the same two operating temperatures as before). Part One (upper graph), Figure 5.5 on page 168, shows the three input signals, I0, I1, and I2, and Part One (lower graph) shows the eight output signals, O0 through O7, in response to the changing input signals. The HSPICE transient analysis listing file is provided as before. See "Listing File for DECODER Transient Analysis @ 25.0C" of Appendix A on page 297.

HSPICE FILE CREATED FOR CIRCUIT DECODER TRANSIENT (PART ONE) @ 25.0C

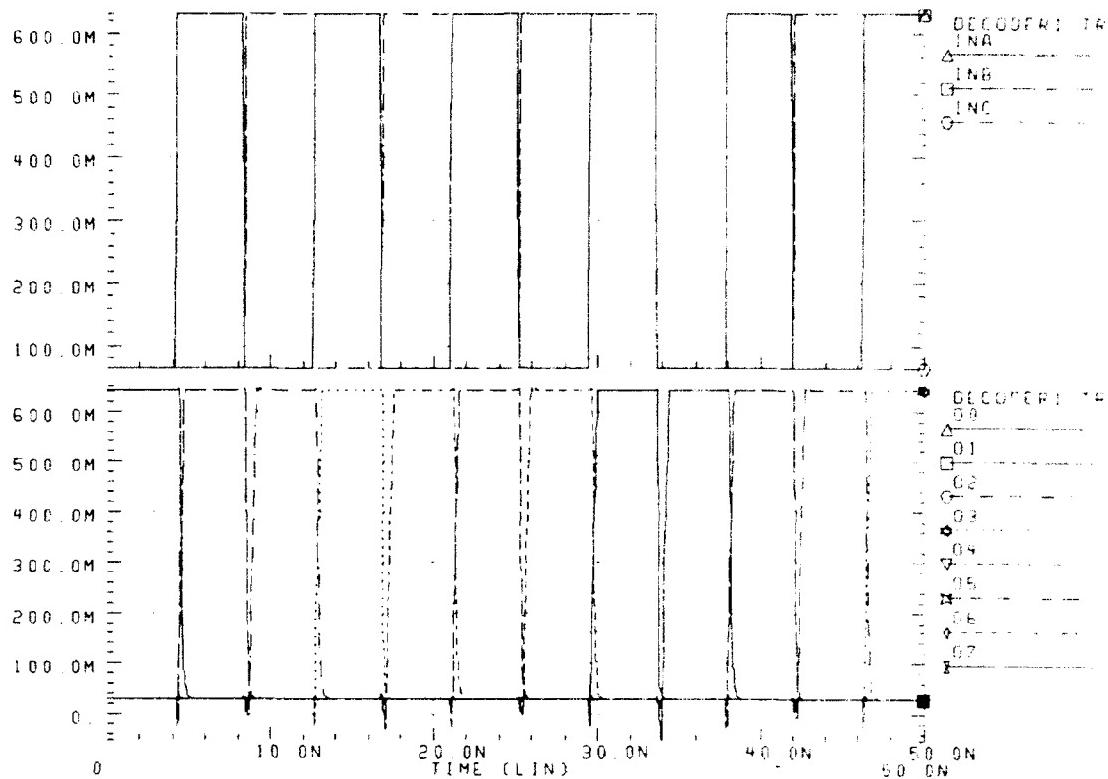


Figure 5.5 DECODER HSPICE Transient Analysis (Part One) at 25.0C

The second part of the DECODER transient analysis, Part Two, see Figure 5.6 on page 169, shows the activation and operation of the ENBL signal (upper graph) and the power dissipation of the DECODER circuit is displayed in the lower graph.

HSPICE FILE CREATED FOR CIRCUIT DECODER: TRANSIENT (PART TWO) & POWER @
25.0C

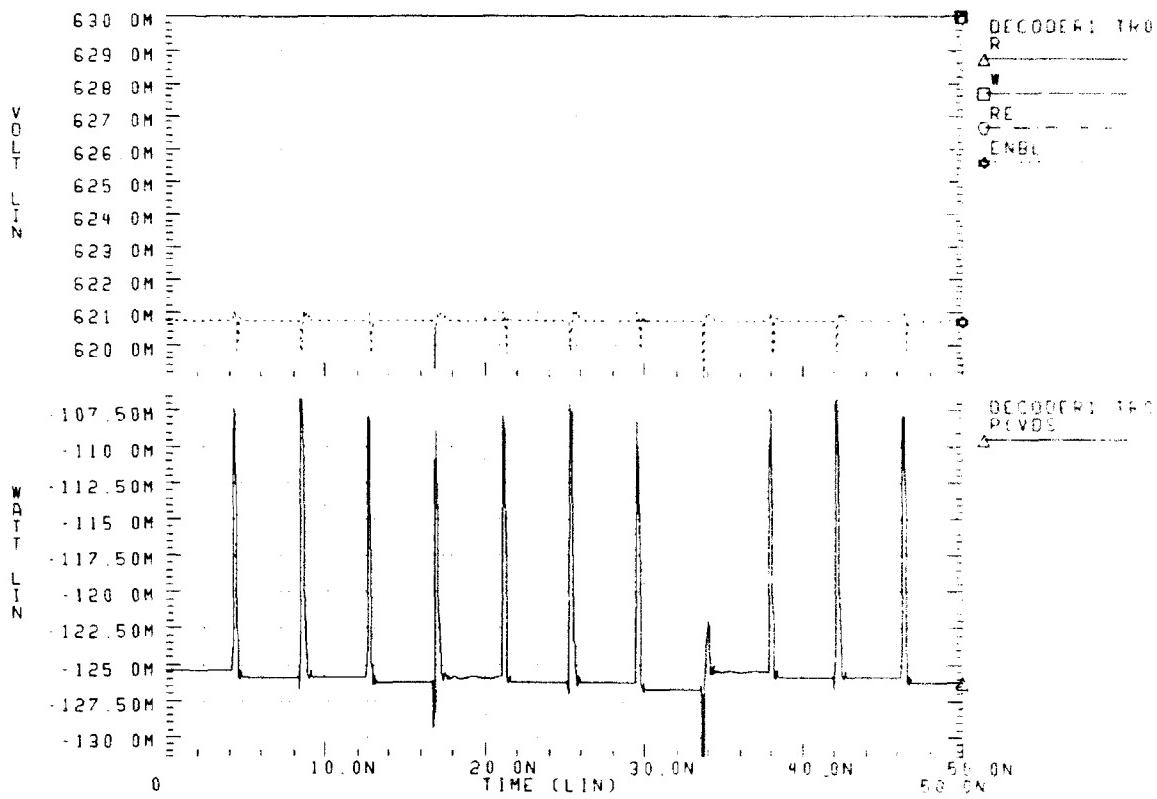


Figure 5.6 DECODER HSPICE Transient Analysis (Part Two) at 25.0C

The same signals as previously described as shown for the DECODER circuit operating at a temperature of 85.0C. See Figure 5.7 on page 170 and Figure 5.8 on page 171. The HSPICE transient analysis listing file is likewise provided.

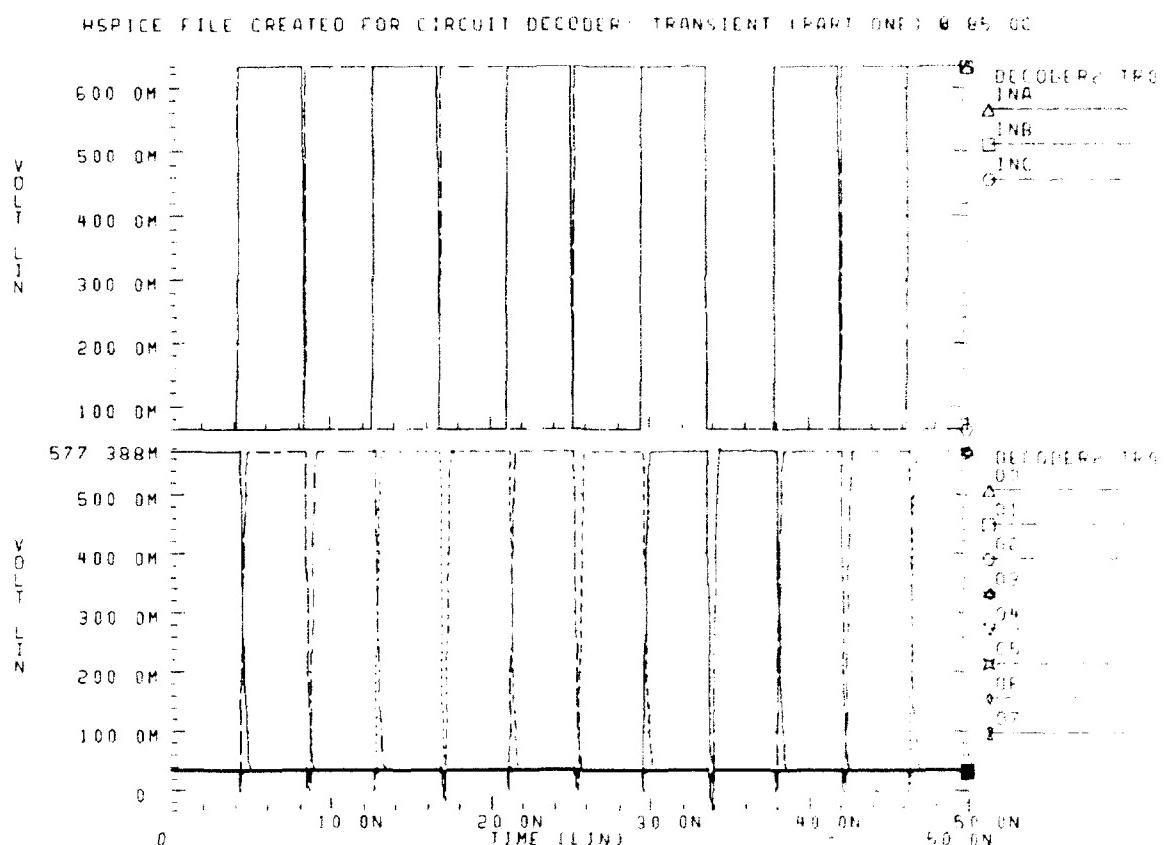


Figure 5.7 DECODER HSPICE Transient Analysis (Part One) at 85.0C

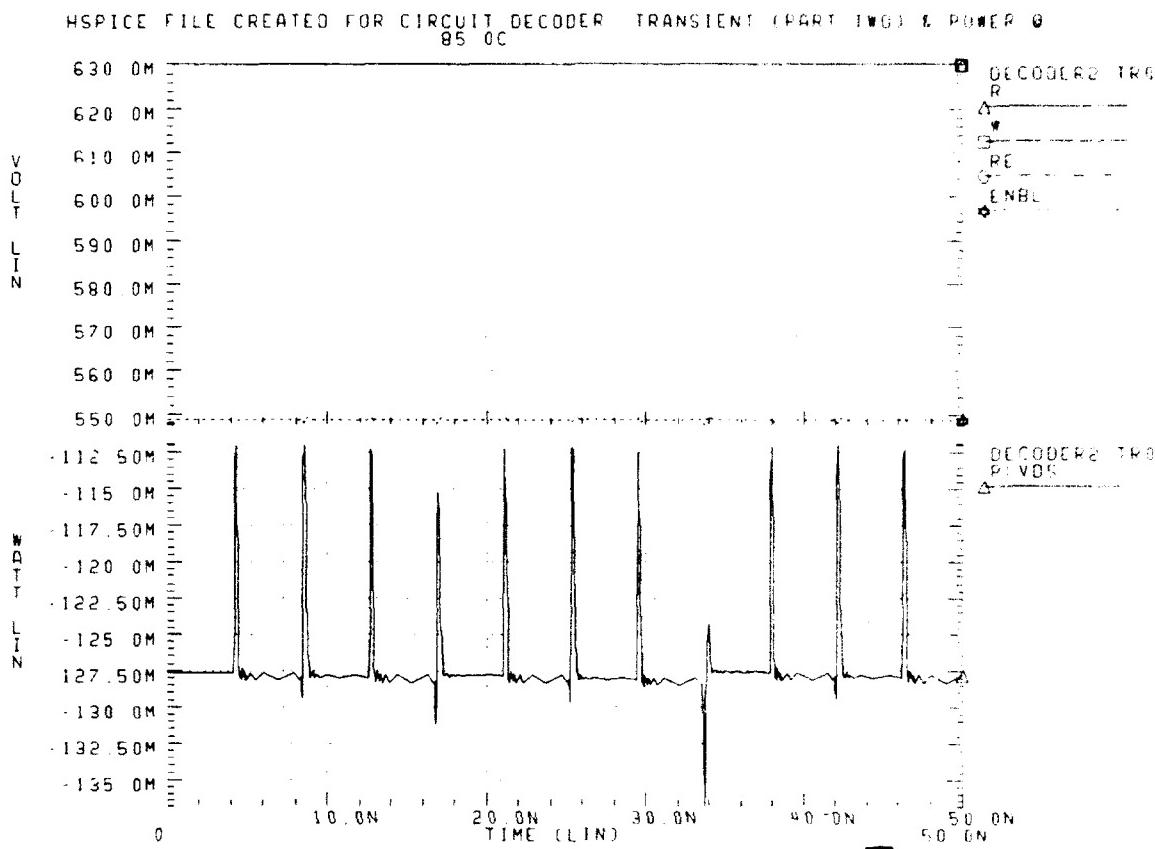


Figure 5.8 DECODER HSPICE Transient Analysis (Part Two) at 85.0C

C. Eight Stage Counter (COUNTER)

A DRAM design requires refresh operation circuitry. This COUNTER circuit is constructed in order to provide the eight counts necessary to access and refresh all eight GaAs DRAM memory array addresses. The COUNTER circuit is used inside a larger circuit entitled DREFRESH which will be covered later in this chapter. Three CPDFF flip-flops are used to maintain each of the eight states between ticks of the input clock signal. The reason for the use of the CPDFF flip-flop is its asynchronous /CLEAR signal which allows a larger circuit to force the COUNTER to a known state at any time. As a side-bar, the name "CPDFF" should really be "CDFF" as the "P" once represented an asynchronous "preset" signal which was later removed from the flip-flop design as it was not necessary to facilitate the requisite logic function.

The COUNTER circuit schematic and logical equivalence diagram is shown in Figure 5.9 on page 172.

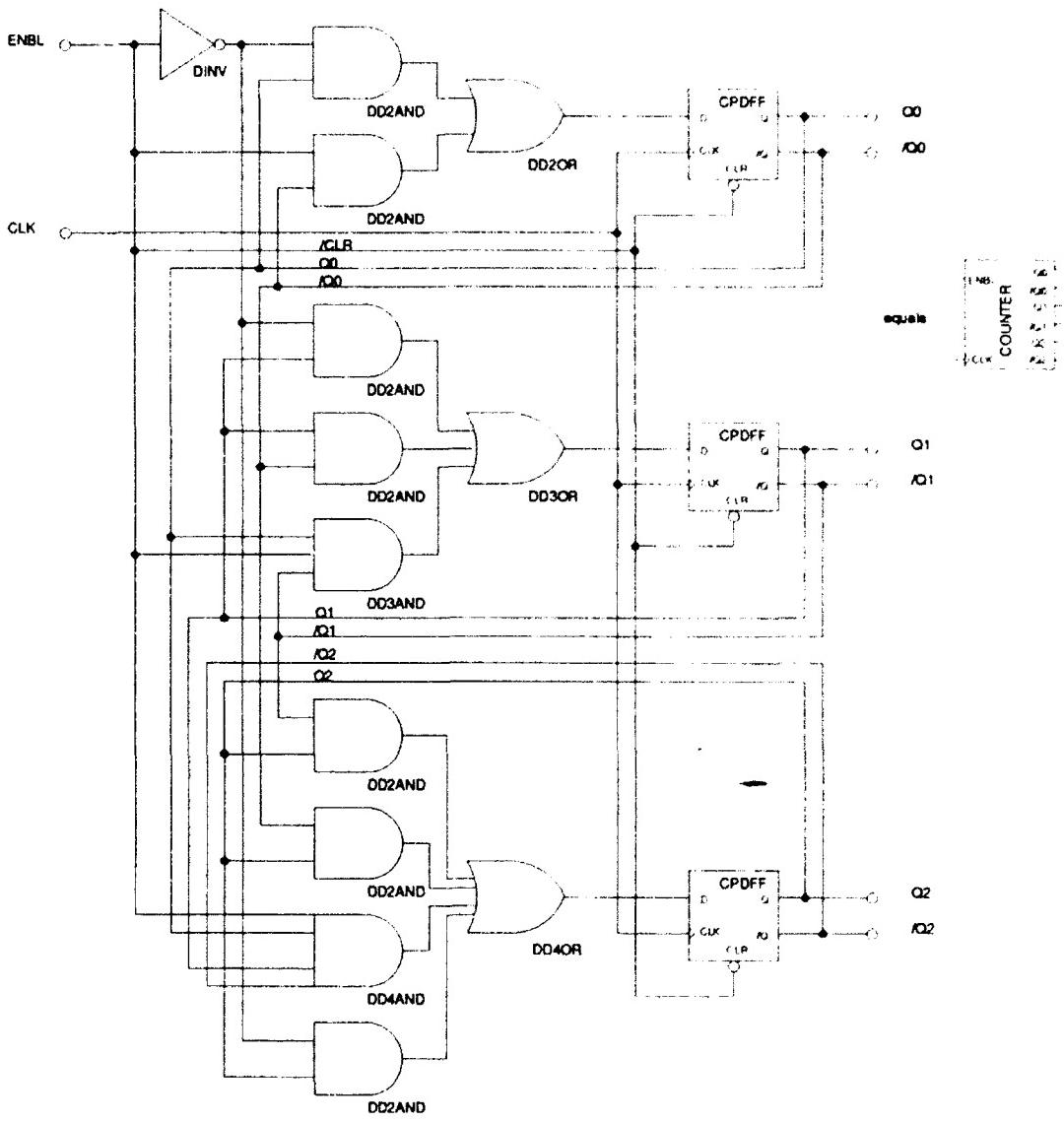


Figure 5.9 COUNTER Schematic and Logical Equivalence

It can be seen in Figure 5.9 on page 160 that the COUNTER circuit is constructed primarily from DCFL glue logic wired such to cause a count of 000 to 111. When the counter is disabled by de-assertion of the ENBL signal (or conversely, assertion of the /CLEAR signal), the COUNTER circuit will output assert /Q0, /Q1, and /Q2 or a positive logic equivalence of 000 for the count. It is interesting to note that because of the

initialization techniques of HSPICE, the COUNTER subcircuit will not begin counting at 000 as it is held in this state by use of the ".IC" statement. Hence, the first count out of the COUNTER is 001. One may see the use of this initial conditions card in the listing file for the transient analysis of the DREFRESH circuit.

The maximum operating frequency of this COUNTER is determined by the DCFL glue logic gate delays but especially, the switching speed of the three counting flip-flops. An interested reader may review the operating characteristics of the DCFL glue logic gates used in the COUNTER circuit by reviewing TABLE 4.1.

The HSPICE transient analysis of the COUNTER circuit may be seen in Figure 5.10 on page 173.

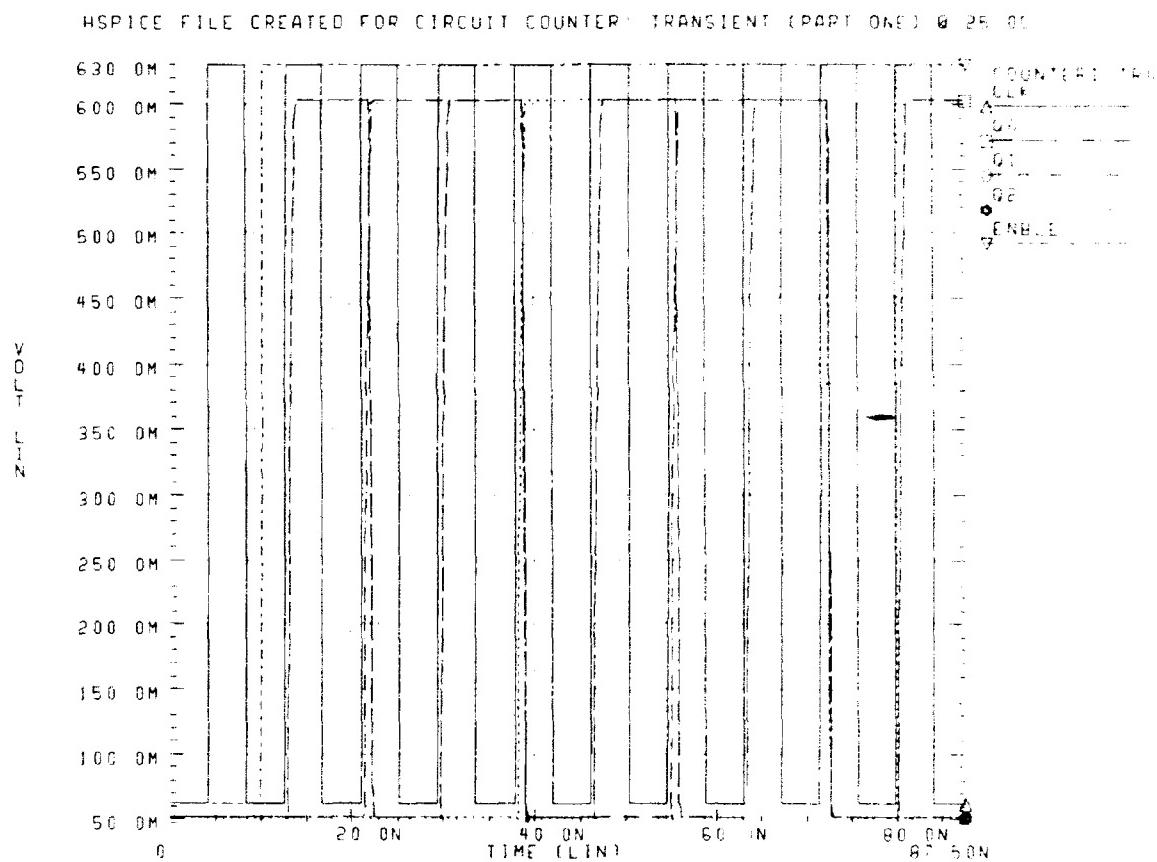


Figure 5.10 COUNTER HSPICE Transient Analysis (Part One) at 25.0C

Figure 5.10 on page 173 shows the first graph associated with the transient analysis of the COUNTER circuit. It contains the input clock signal (CLK), the input enable signal (ENBLE), and provides the "Q" outputs of the three aforementioned counting flip-flops. Standard DCFL loads of two DINVs were placed on

each "Q" output to represent realistic loading conditions. One can see from Figure 5.10 on page 173 that the counter begins counting at "001" which occurs for the HSPICE simulator initialization reasons mentioned earlier. The second part of the HSPICE transient analysis of the COUNTER circuit may be seen in Figure 5.11 on page 174.

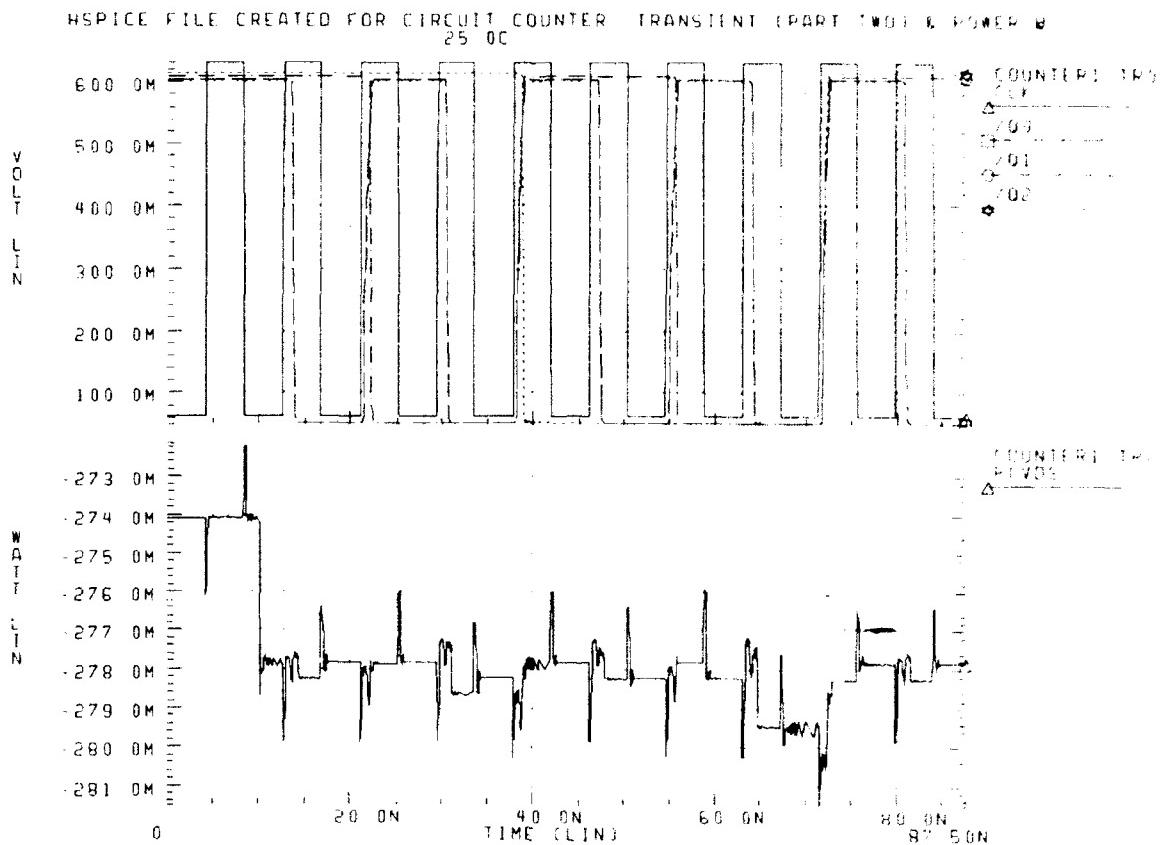


Figure 5.11 COUNTER HSPICE Transient Analysis (Part Two) & Power at 25.0C

Figure 5.11 on page 174 is derived from the same single simulator run as the previous graph. It was believed to be easier to see the results if the graph was not cluttered with too many plots. Figure 5.11 shows the "/Q" output signals in the upper graph superimposed with the exact same input clock signal (CLK). It may be seen in Figure 5.11 that the "/Q" output signals act as expected as logical inverse signals of the "Q" output signals seen in the first part of the transient analysis of the COUNTER circuit as shown in Figure 5.10 on page 173. The lower graph of Figure 5.11 indicates the power dissipation of the COUNTER circuit as it counts

through all possible states. See "Listing File for COUNTER Transient Analysis @ 25.0C" of Appendix A on page 305.

The COUNTER circuit was also simulated under the same operating conditions except the nominal temperature was increased from 25.0C to 85.0C. See Figure 5.12 on page 175 and Figure 5.13 on page 176.

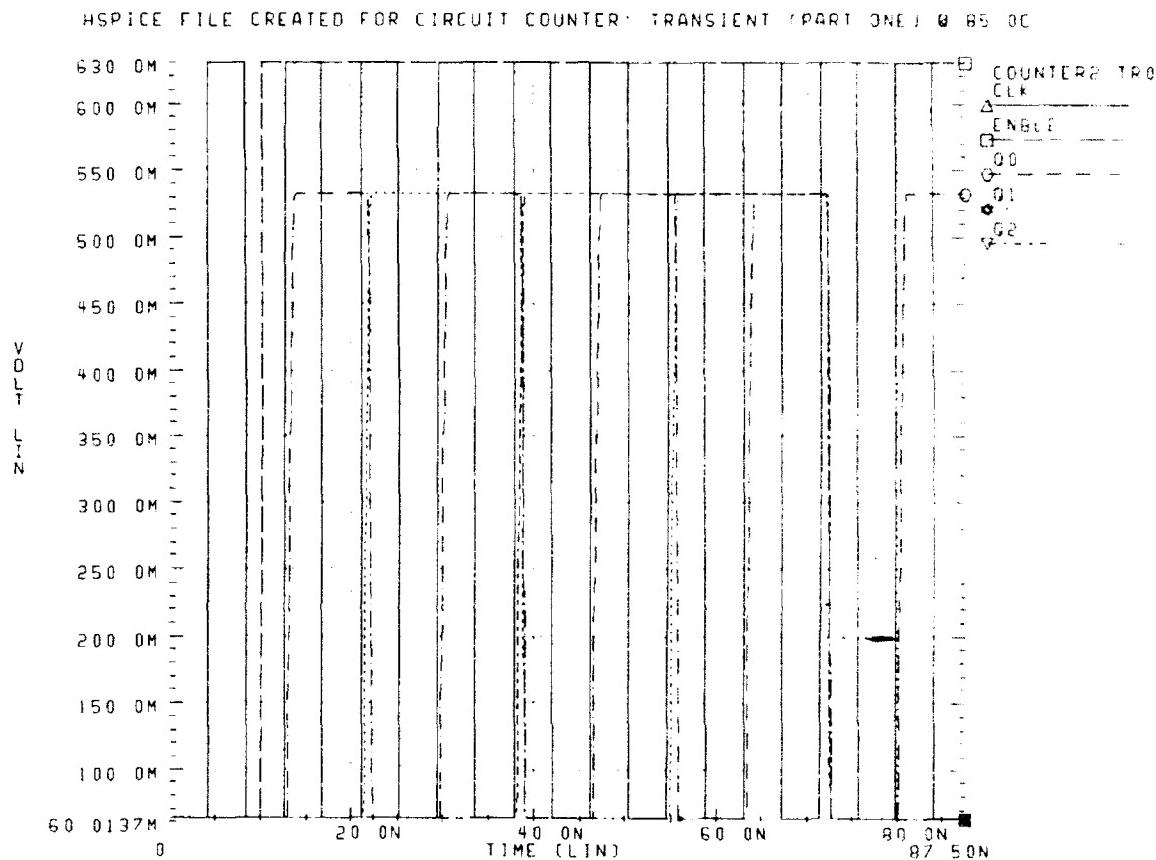


Figure 5.12 COUNTER HSPICE Transient Analysis (Part One) at 85.0C

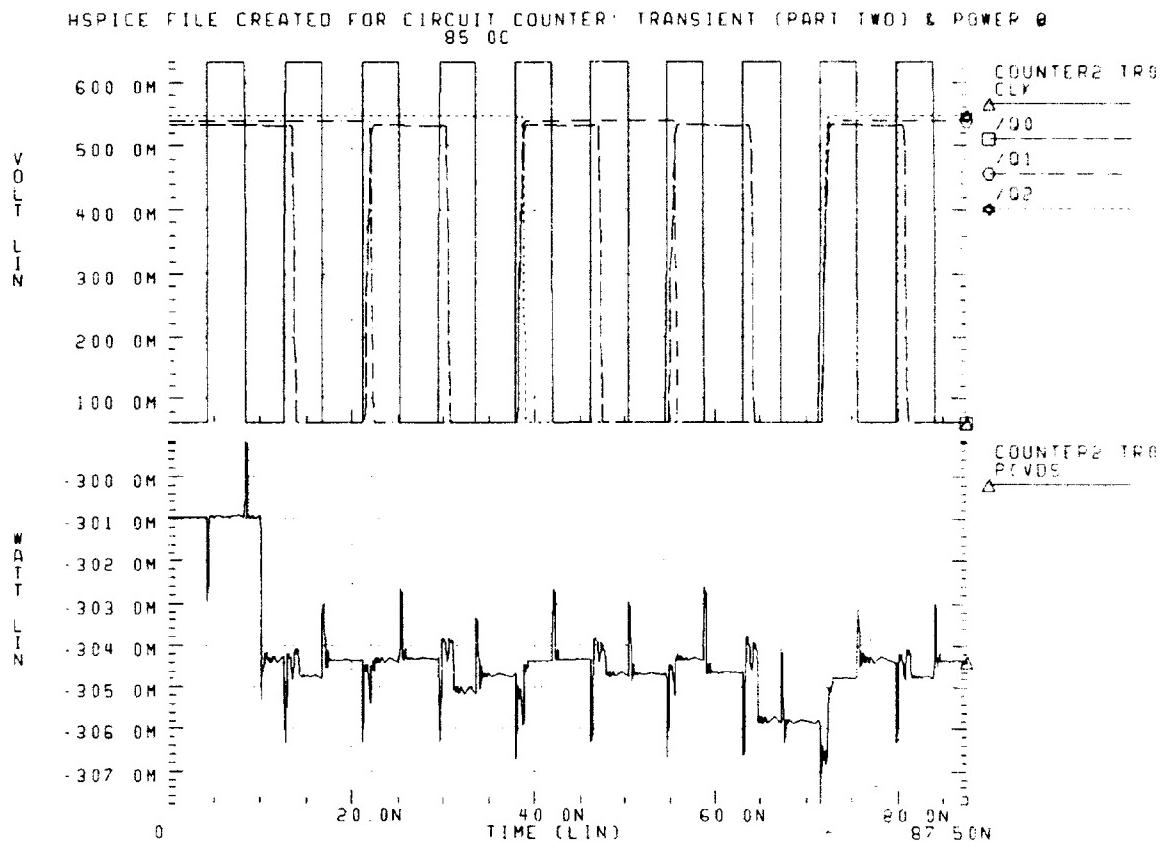


Figure 5.13 COUNTER HSPICE Transient Analysis (Part Two) & Power at 85.0C

D. DRAM Refresh Circuitry (DREFRESH)

A dynamic RAM requires periodic recharging of the storage element charges, else the charges leak away. The DREFRESH circuit provides the necessary logic function to control the refresh operation for the GaAs DRAM memory array. See Figure 5.14 on page 177 for the DREFRESH schematic and logical equivalence.

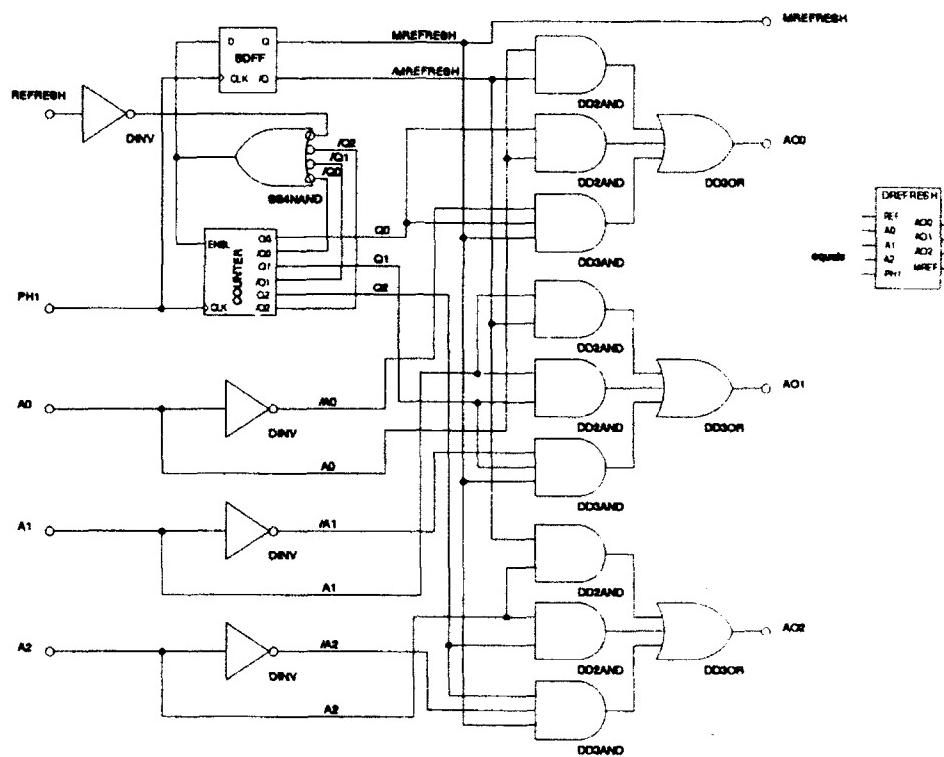


Figure 5.14 DREFRESH Schematic and Logical Equivalence

In words, the purpose of this circuit is to monitor the REFRESH signal and be prepared to act upon its assertion when ANDed with a PH1 clock pulse. When the DREFRESH circuit detects the assertion of the external REFRESH signal, it is designed to detect the “level” of the REFRESH signal and cause the SDFF to be set asserting MREFRESH to the rest of the GaAs DRAM memory array circuitry. This MREFRESH signal (occasionally abbreviated “MREF”), among other actions, asserts the memory busy signal, MBSY, to the rest of the GaAs DRAM memory array circuitry and off-chip and overrides the assertion of the READ or WRITE signal (the WRITEP circuit performs this function, it will be discussed later).

It was previously mentioned that the COUNTER circuit simulation required the use of the HSPICE “.IC” statement in order to force the circuit into a known state. One can see that if the circuit simulator HSPICE initializes the COUNTER to some arbitrary value (not 000, e.g., Q0=LOW, Q1=LOW, Q2=LOW, /Q0=HIGH, /Q1=HIGH, and /Q2=HIGH) then on the next PH1 clock pulse, the SDFF will see a HIGH on its D input and be set indicating MREFRESH by the next PH1 clock pulse falling edge. Additionally, the same

PH1 clock pulse will cause the COUNTER to count further into the REFRESH cycle. Now, this is an anomaly of the HSPICE simulation initialization routine, but, the first time, each time, this GaAs DRAM circuit is powered up, the COUNTER will come up in some unknown state and count through until the last refresh state and then the COUNTER and DREFRESH will enter a known state.

The second major function of this circuit is to choose between passing through the off-chip input address lines (A2 to A0) to the DREFRESH output address lines (AO2 to AO0) or passing through the addresses generated by the refresh sub-portion of the DREFRESH circuit.

As previously mentioned, the SDFF flip-flop will be set upon the assertion of the REFRESH signal ANDed with the COUNTER being at "000" and the next PH1 clock pulse, and the DREFRESH circuit will enter into a refresh operation. During the refresh operation, the external address signal inputs, A2 to A0, will be ignored and the address signals generated by the refresh circuitry will be passed through to the DREFRESH output address lines (AO2 to AO0) thereby causing the eight addresses of the GaAs DRAM memory array to be sequentially READ which is sufficient to refresh each storage element charge. For additional detailed information regarding the refresh of the individual charges, see the excellent and thorough work of Vagts [Ref. 8:pp. 20-22]. In the interest of brevity and by virtue of the DREFRESH circuit simplicity, the design state diagrams and Karnaugh mappings are not shown.

The DREFRESH transient analysis is demonstrated in the next eight graphs. As before, the graphs are kept to a few signals each to facilitate easier understanding. It is interesting to note that in order to better simulate DREFRESH reality, the GaAs DRAM memory array CLOCK circuit was included in the HSPICE file and used to generate the DREFRESH input clock signal, PH1. See "Listing File for DREFRESH Transient Analysis @ 25.0C" of Appendix A on page 315.

The first graph, see Figure 5.15 on page 179, shows the plot of the input clock signal, PH1, and the assertion of the external REFRESH signal and the resulting assertion of the MREFRESH signal upon the first edge of the PH1 signal.

HSPICE FILE CREATED FOR CIRCUIT DREFRESH TRANSIENT (PART ONE) 25.0C

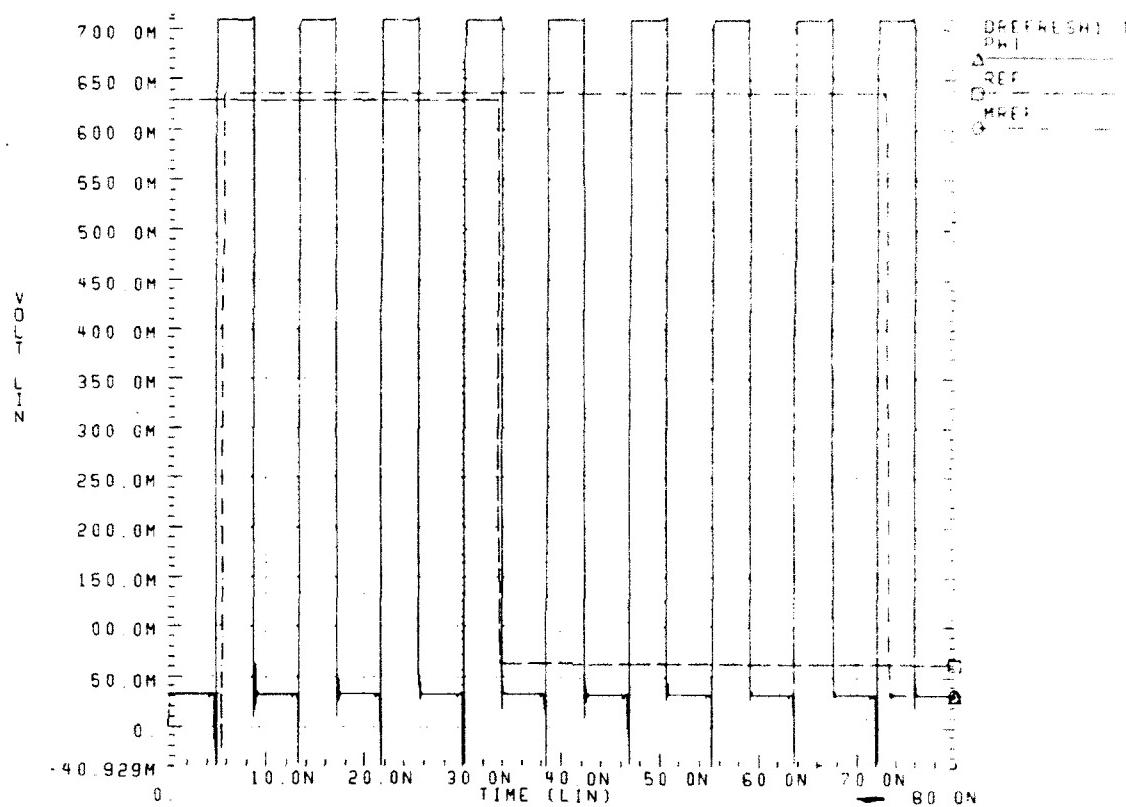


Figure 5.15 DREFRESH HSPICE Transient Analysis (Part One) at 25.0C

The next DREFRESH transient analysis graph, see Figure 5.16 on page 180, shows the CLOCK input signal, PH1, and the external input address lines, A2 to A0. It can be seen that the external input address lines are counting through the eight possible addresses.

HSPICE FILE CREATED FOR CIRCUIT DREFRESH TRANSIENT (PART TWO) 825 DC

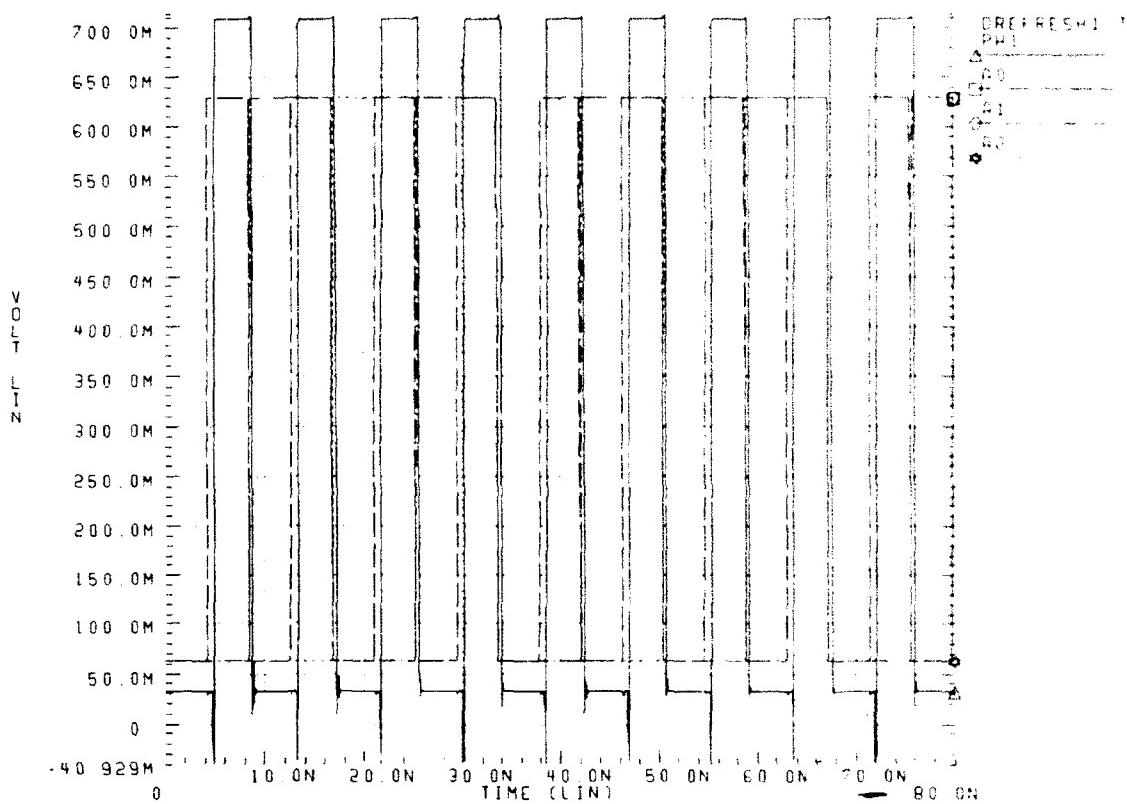


Figure 5.16 DREFRESH HSPICE Transient Analysis (Part Two) at 25.0C

The next DREFRESH transient analysis graph, see Figure 5.17 on page 181, shows the CLOCK input signal, PH1, the MREFRESH signal, and the DREFRESH output address lines, AO2 to AO0. It can be seen that the DREFRESH output address lines are counting through the eight possible addresses. Notice that the MREFRESH signal is de-asserted upon completion of the final GaAs DRAM memory array refresh.

HSPICE FILE CREATED FOR CIRCUIT DREFRESH: TRANSIENT (PART THREE) 825.0C

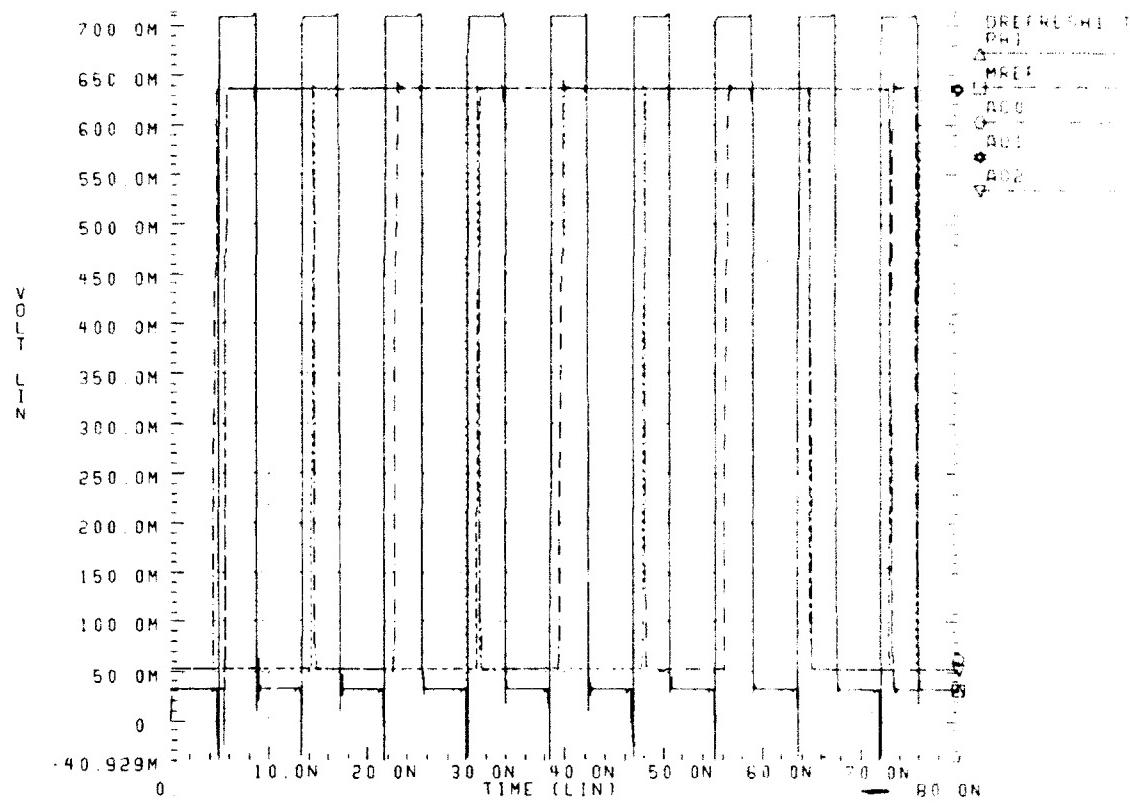


Figure 5.17 DREFRESH HSPICE Transient Analysis (Part Three) at 25.0C

The next DREFRESH transient analysis graph, see Figure 5.18 on page 182, shows the power dissipation.

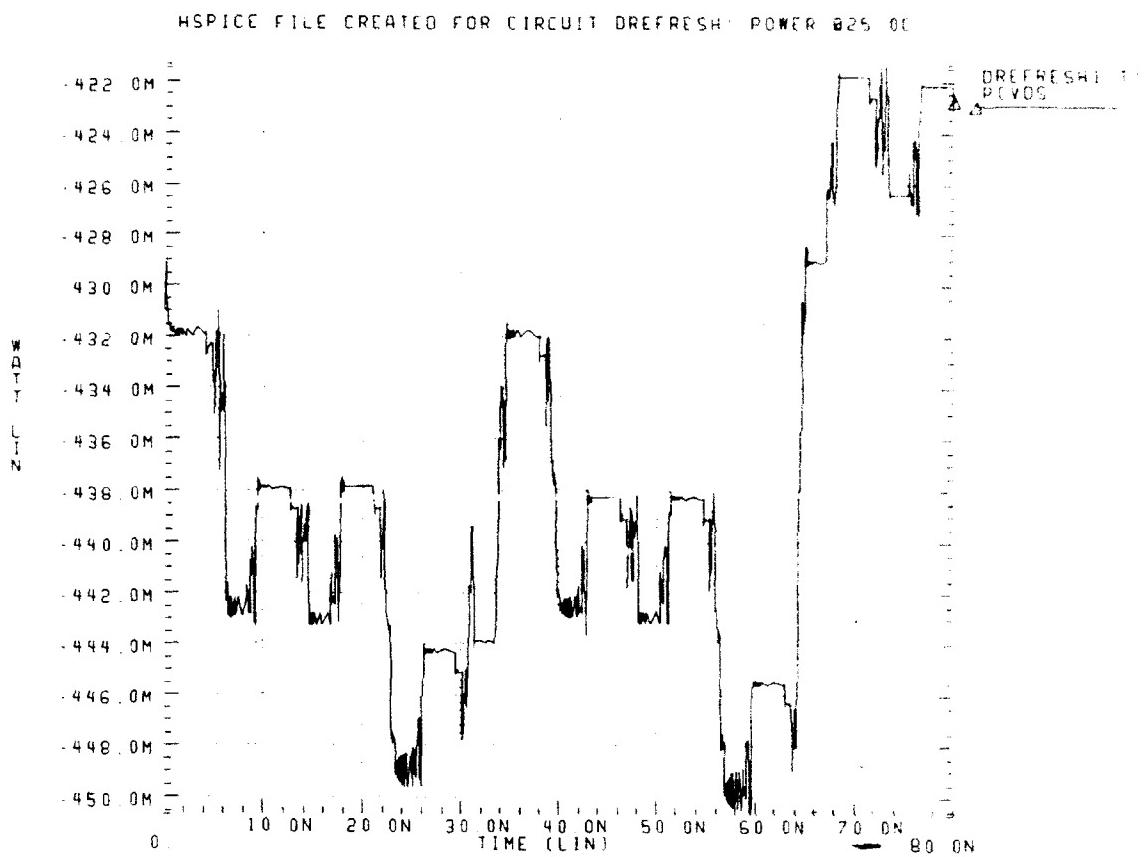


Figure 5.18 DREFRESH HSPICE POWER at 25.0C

The following four DREFRESH graphs show the same signals as discussed in the preceding paragraphs, but, using a simulation nominal temperature of 85.0C. See Figure 5.19 on page 183, Figure 5.20 on page 184, Figure 5.21 on page 185, and Figure 5.22 on page 186.

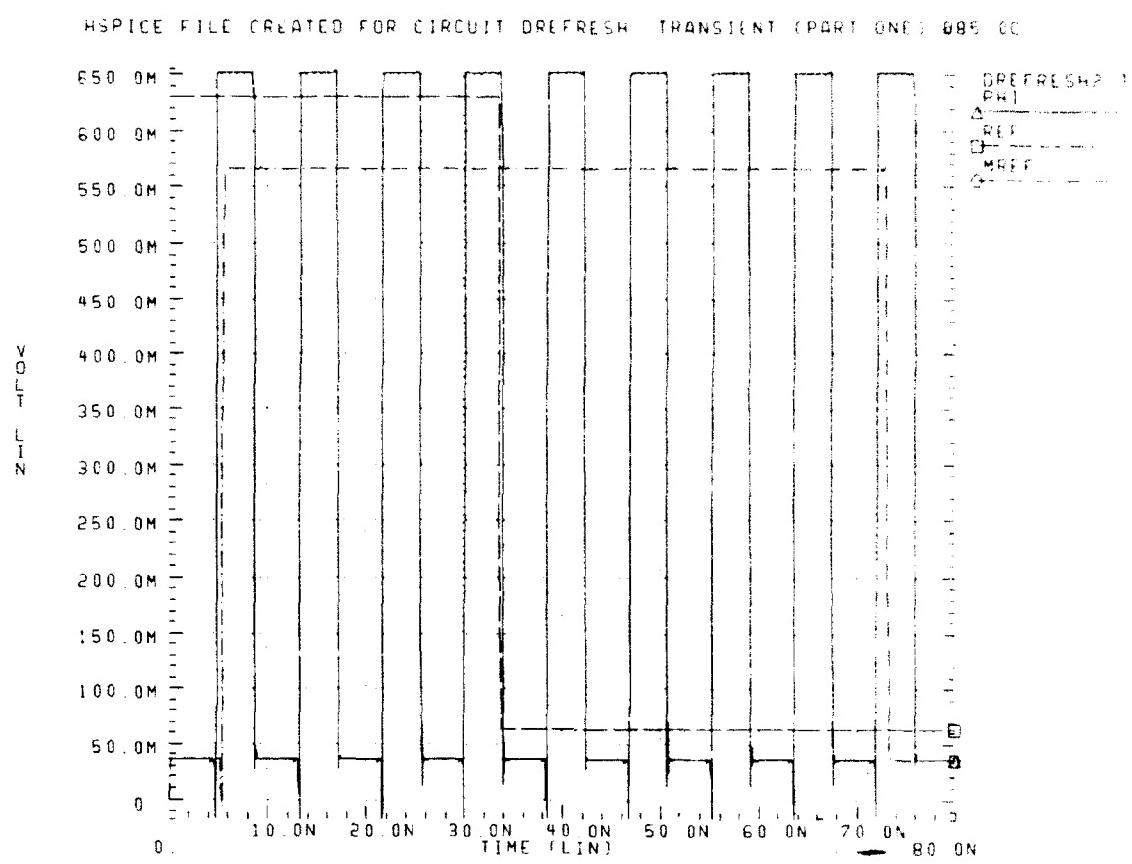


Figure 5.19 DREFRESH HSPICE Transient Analysis (Part One) at 85.0C

HSPICE FILE CREATED FOR CIRCUIT DREFRESH TRANSIENT (PART TWO) 885.00

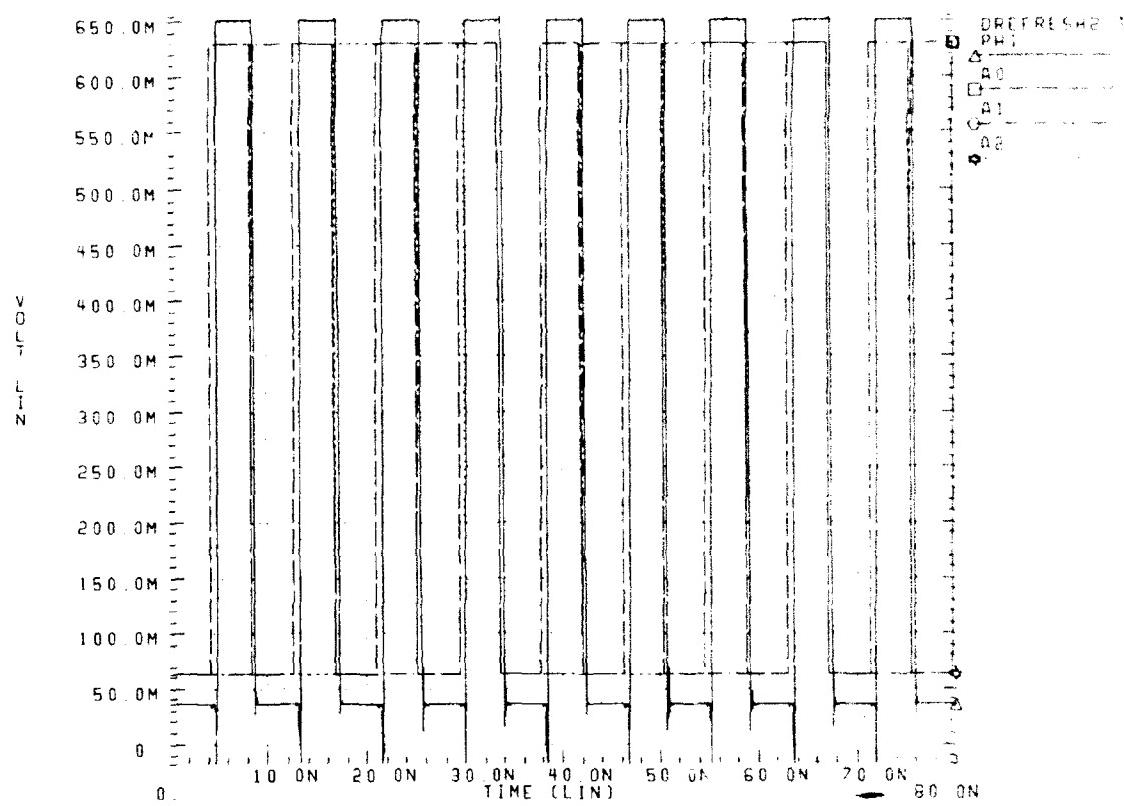


Figure 5.20 DREFRESH HSPICE Transient Analysis (Part Two) at 85.0C

HSPICE FILE CREATED FOR CIRCUIT DREFRESH1 TRANSIENT (PART THREE) @85.0C

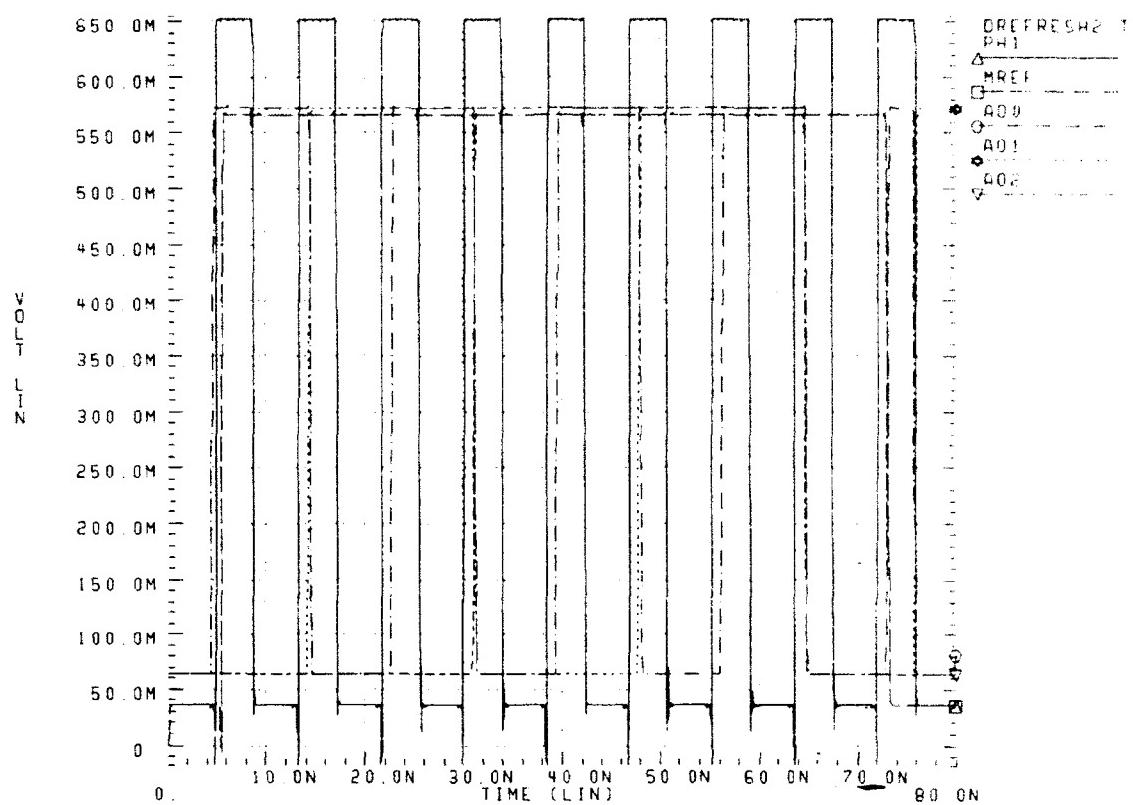


Figure 5.21 DREFRESH HSPICE Transient Analysis (Part Three) at 85.0C

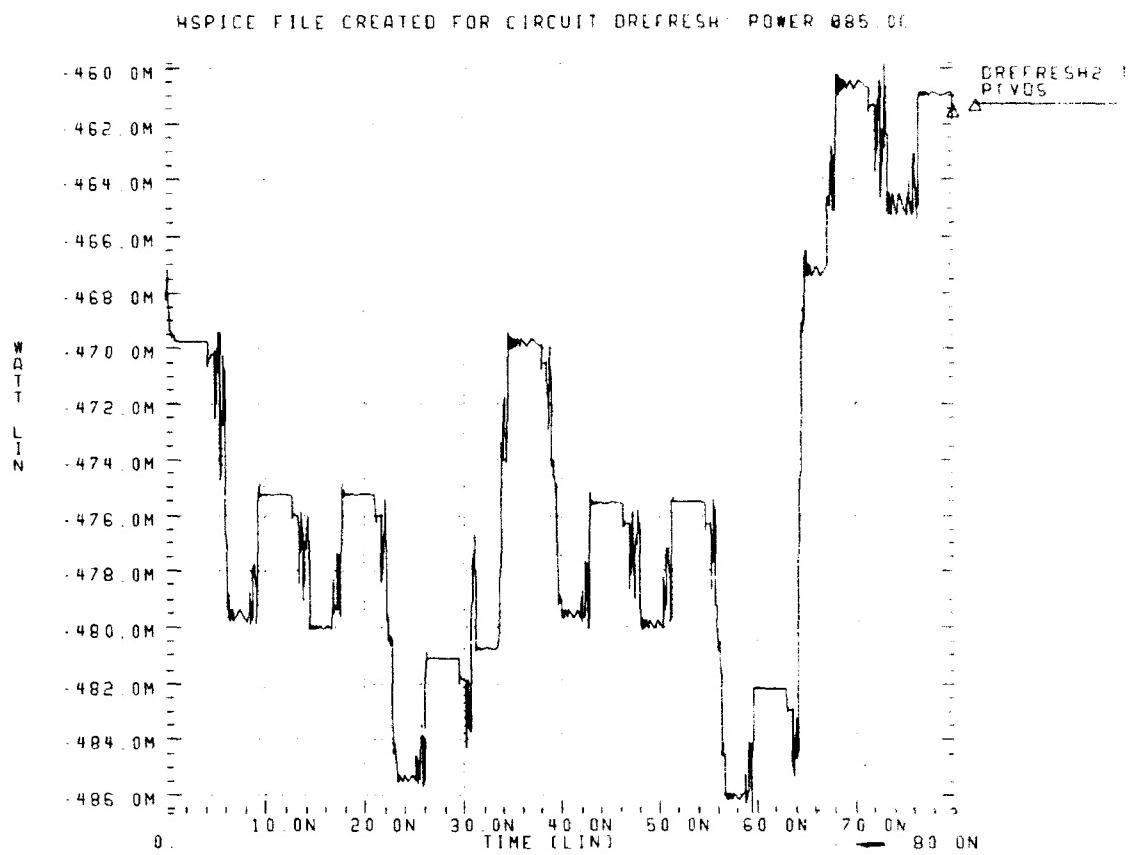


Figure 5.22 DREFRESH HSPICE POWER at 85.0C

E. Decoder Driver Circuit (DECODDRVER)

The purpose of the decoder driver circuit, DECODDRVER, is to synchronize the decoder generated address signals to the correct GaAs DRAM memory array CLOCK signal. Additionally, the DECODDRVER circuit generates the actual level-shifted pulses to actuate the GaAs MESFETs which are the access points to the fundamental charge storage elements, the parallel plate capacitors, of the GaAs DRAM memory array. Through experimentation, it was determined that the appropriate GaAs DRAM memory array CLOCK signal is the PH2D signal. For a thorough discussion of the reasons behind why this is so, see [Ref. 8:pp. 12-14]. In addition, the writing and reading operation requisite control signals, EDUM, ODUM, EDUMD, and ODUMD, are generated. These signals refer to the operations of the "dummy" cells, one on each side of the differential sense amplifier in the GaAs DRAM memory array. These signals are used by two other circuits, the OUTPUT circuit and the RAM_ARRAY circuit, both of which will be discussed later in this chapter.

See Figure 5.23 on page 187 for the DECODDRVER schematic and logical equivalence.

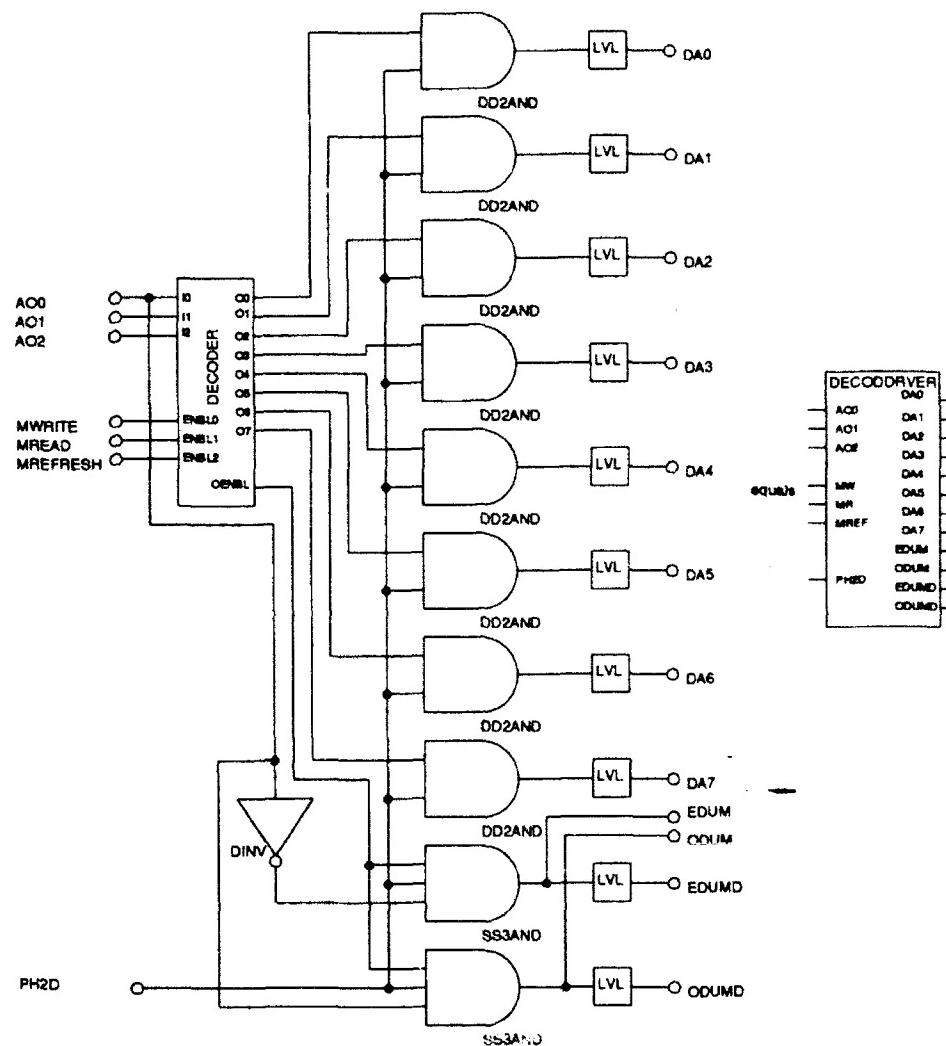


Figure 5.23 DECODDRVER Schematic and Logical Equivalence

The DECODDRVER circuit transient analysis is presented in the following eight figures. As before, the graphs are kept to a few signals each to facilitate easier understanding. It is interesting to note that in order to better simulate DECODDRVER reality, the GaAs DRAM memory array CLOCK and DREFRESH circuits were included in the HSPICE file and used to generate the following DECODDRVER input signals: PH1, AO0, AO1, AO2, and MREFRESH. See Figure 5.24 on page 188 for the DECODDRVER transient analysis (part one). See "Listing File for DECODDRVER Transient Analysis @ 25.0C" of Appendix A on page 333.

HSPICE FILE CREATED FOR CIRCUIT DECODDRVER TRANSIENT (PART ONE) B15.01

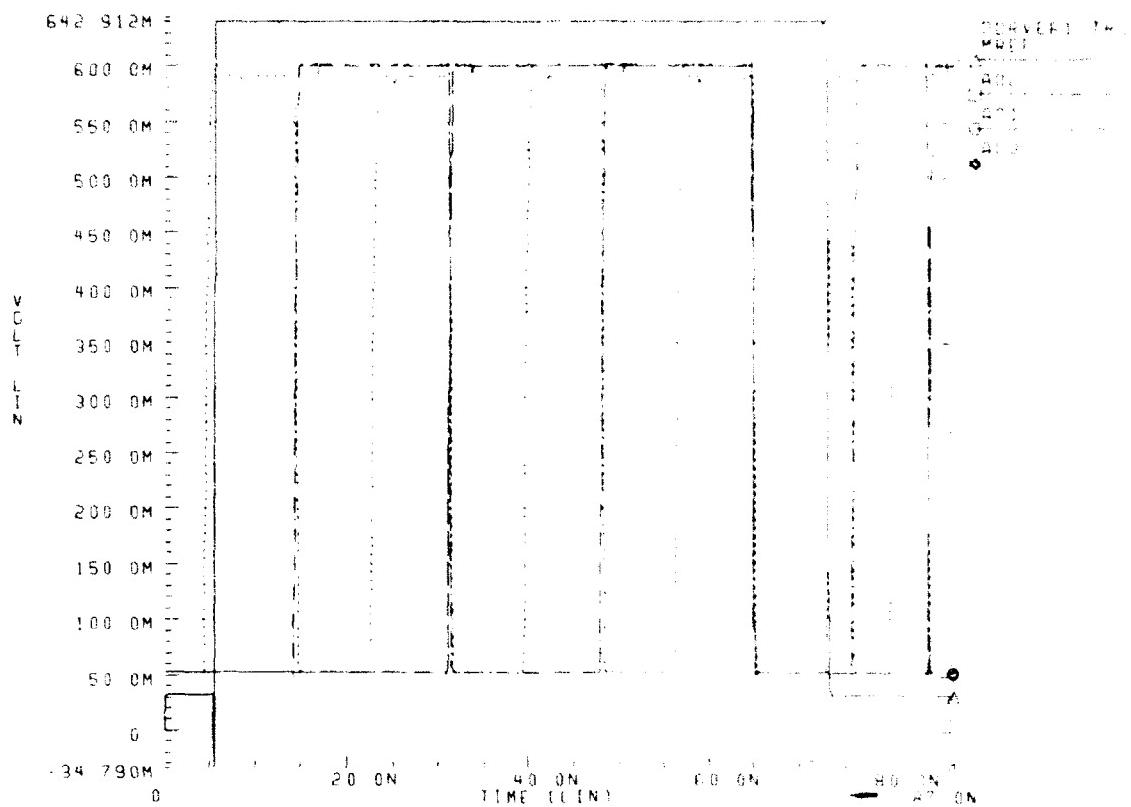


Figure 5.24 DECODDRVER HSPICE Transient Analysis (Part One) at 25.0C

Looking at Figure 5.24 on page 188, one may see the signals MREFRESH (MREF) and AO2 to AO0, as generated by the DREFRESH circuit and as inputs to the DECODDRVER circuit. The next figure, Figure 5.25 on page 189, shows the MREFRESH signal, the input CLOCK signal PH2D, and the eight "DA" signals, DA7 to DA0.

HSPICE FILE CREATED FOR CIRCUIT DECODDRVER TRANSIENT (PART TWO) 25.0C

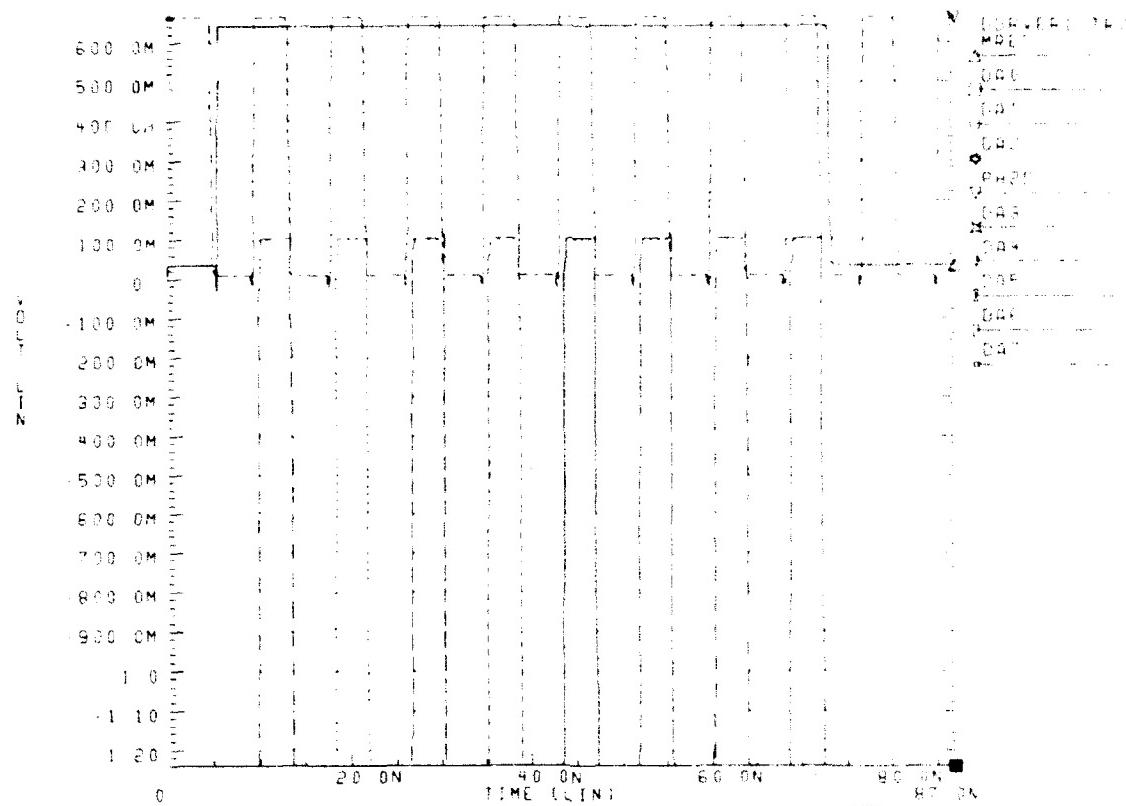


Figure 5.25 DECODDRVER HSPICE Transient Analysis (Part Two) at 25.0C

The third figure of the DECODDRVER transient analysis (part three), see Figure 5.26 on page 190, shows the aforementioned read and write control signals, EDUM, ODUM, EDUMD, and ODUMD.

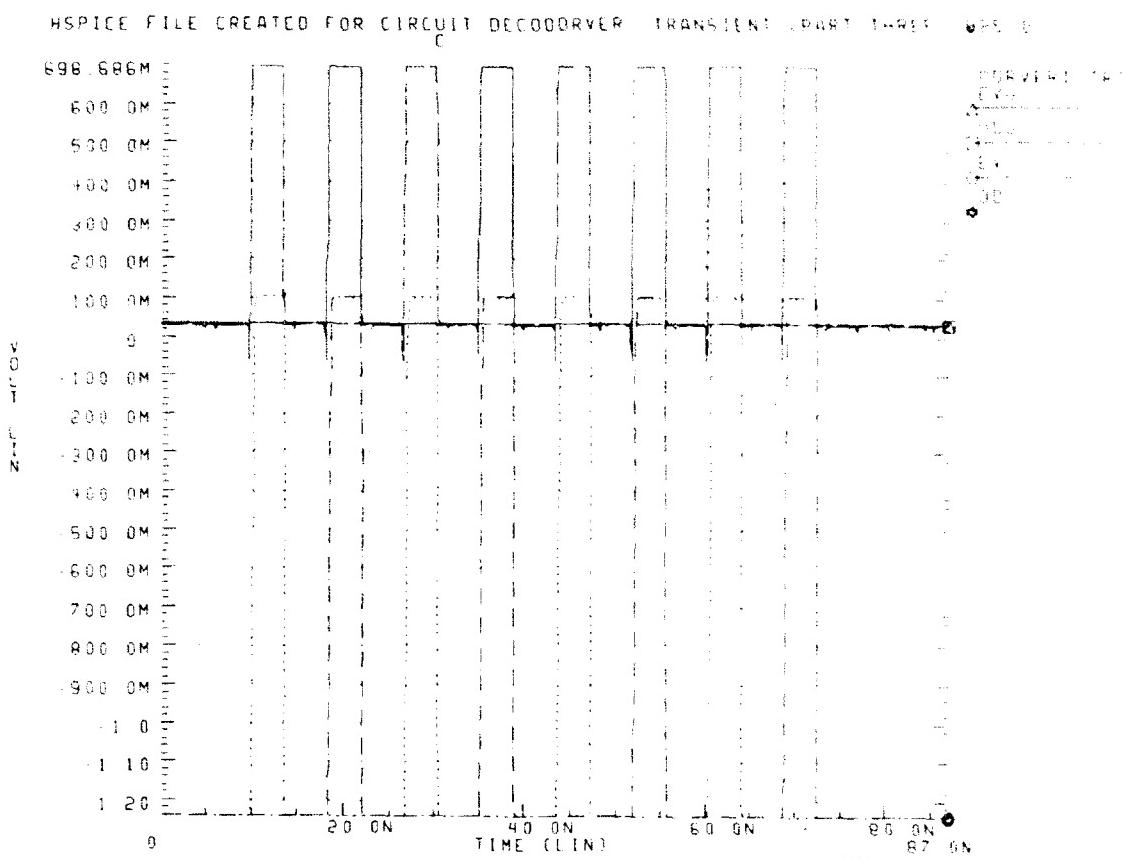


Figure 5.26 DECODDRVER HSPICE Transient Analysis (Part Three) at 25.0C

The fourth figure of the DECODDRVER transient analysis, see Figure 5.27 on page 191, presents the power dissipation of the circuit simulated at a nominal temperature of 25.0C.

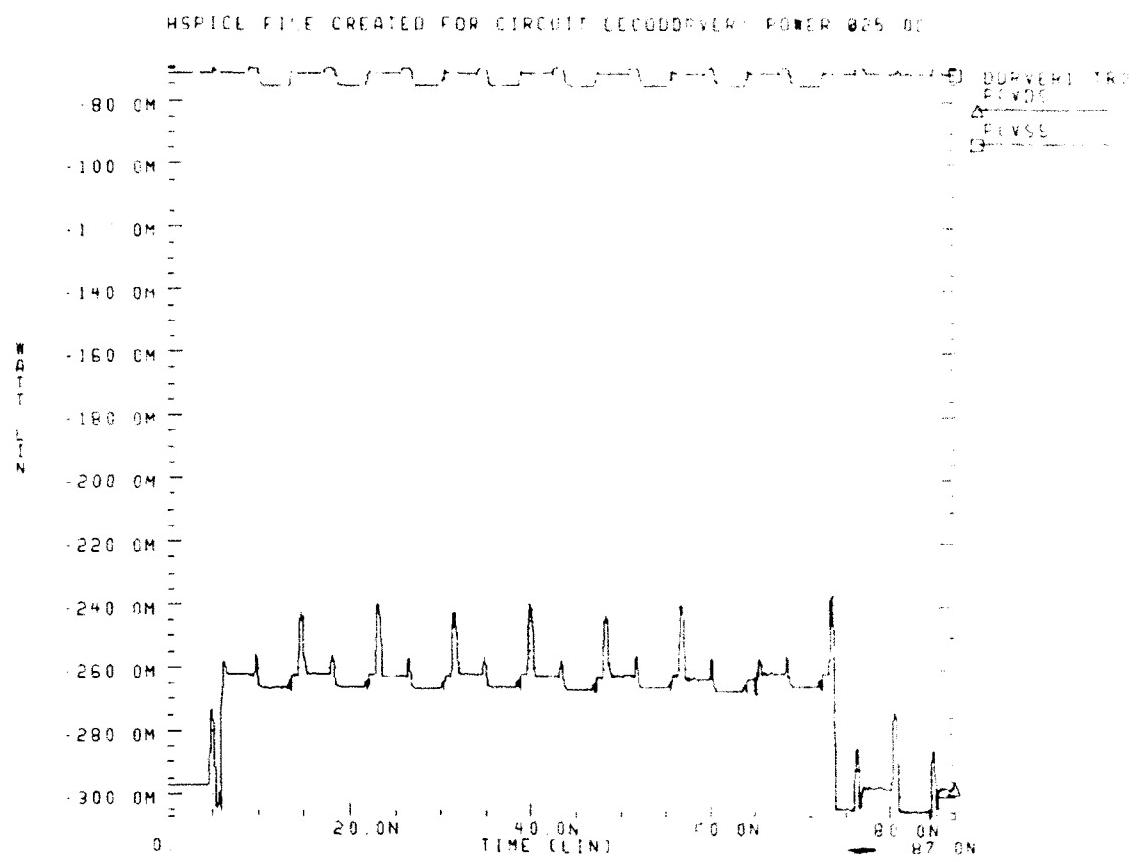


Figure 5.27 DECODDRVER HSPICE POWER at 25.0C

The following four DECODDRVER graphs show the same signals as discussed in the preceding paragraphs, but, a simulation nominal temperature of 85.0C. See Figure 5.28 on page 192, Figure 5.29 on page 193, Figure 5.30 on page 194, and Figure 5.31 on page 195.

HSPICE FILE CREATED FOR CIRCUIT DECODDRVER TRANSIENT (PART ONE) @85.0C

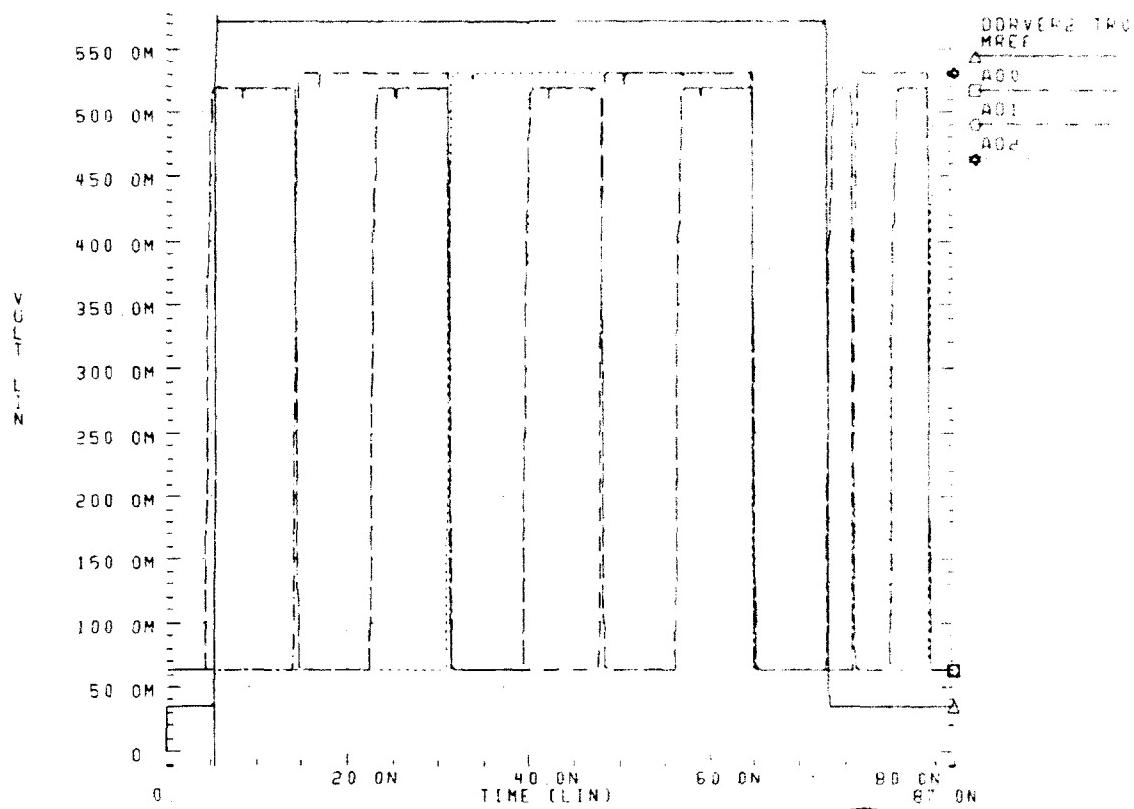


Figure 5.28 DECODDRVER HSPICE Transient Analysis (Part One) at 85.0C

HSPICE FILE CREATED FOR CIRCUIT DECODDRVER: TRANSIENT (PART TWO) 885 OF

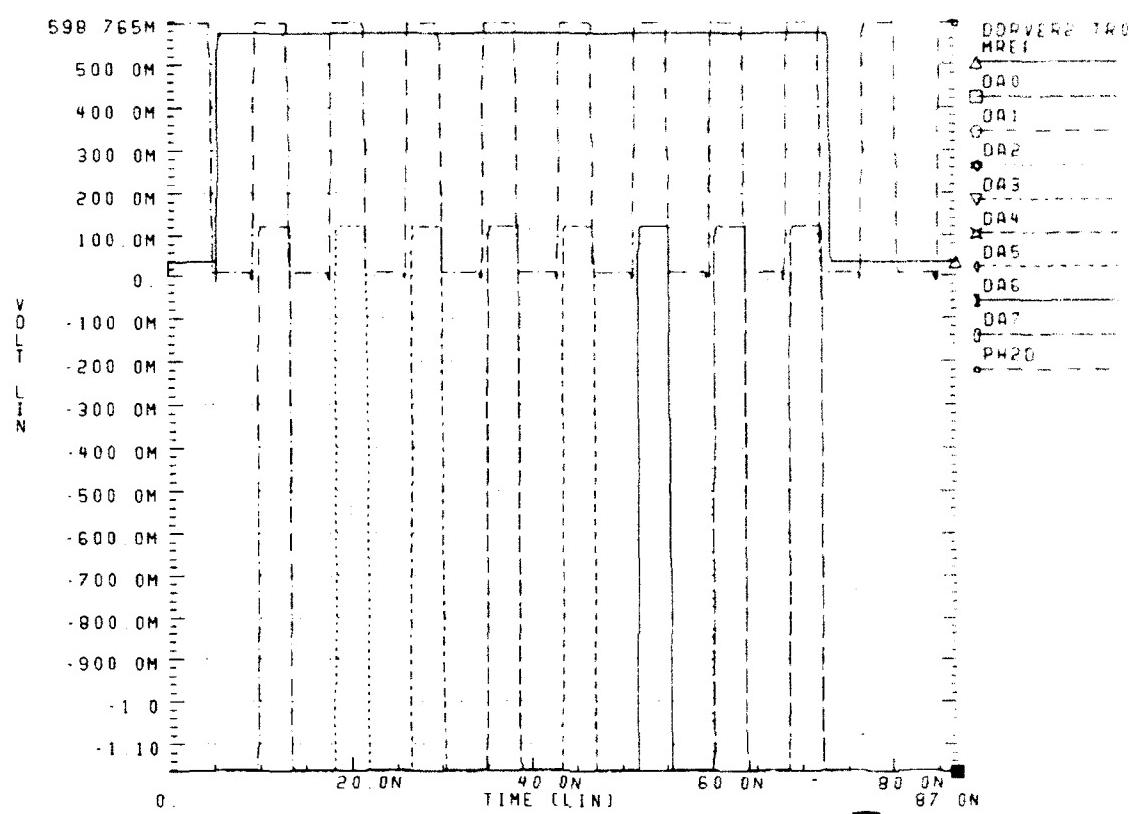


Figure 5.29 DECODDRVER HSPICE Transient Analysis (Part Two) at 85.0C

HSPICE FILE CREATED FOR CIRCUIT DECODDRVER: TRANSIENT (PART THREE) 085.0

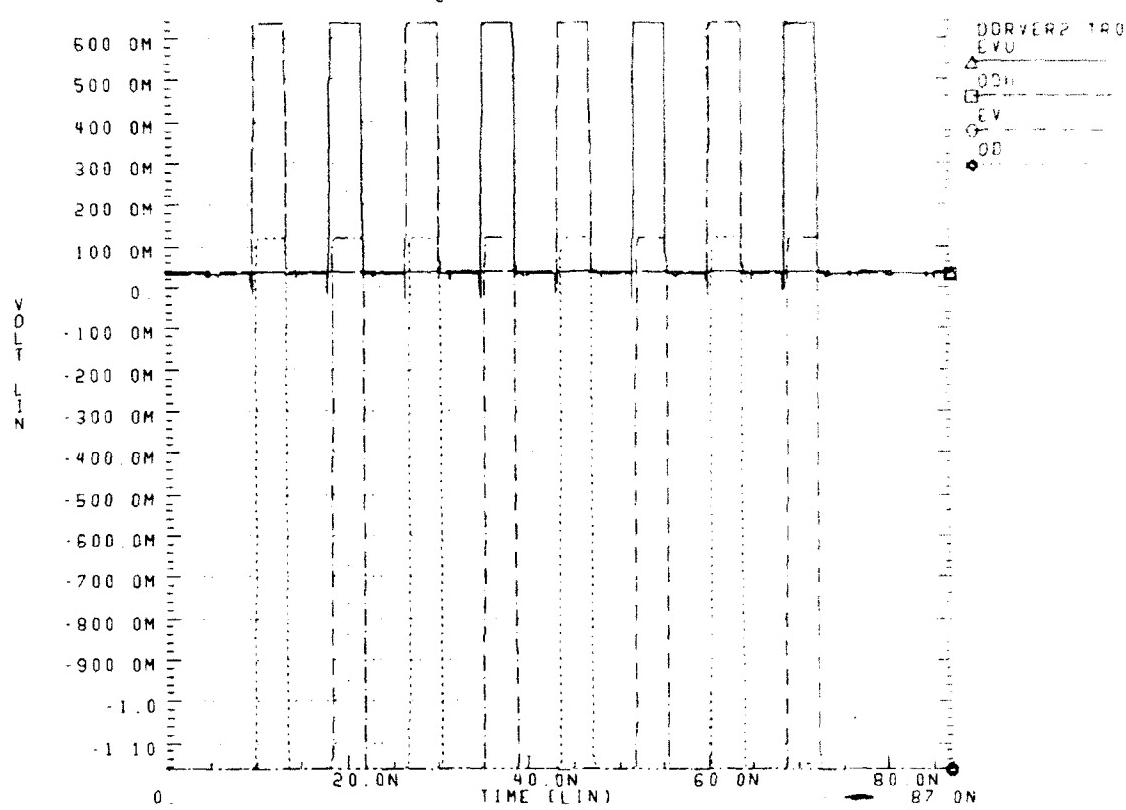


Figure 5.30 DECODDRVER HSPICE Transient Analysis (Part Three) at 85.0C

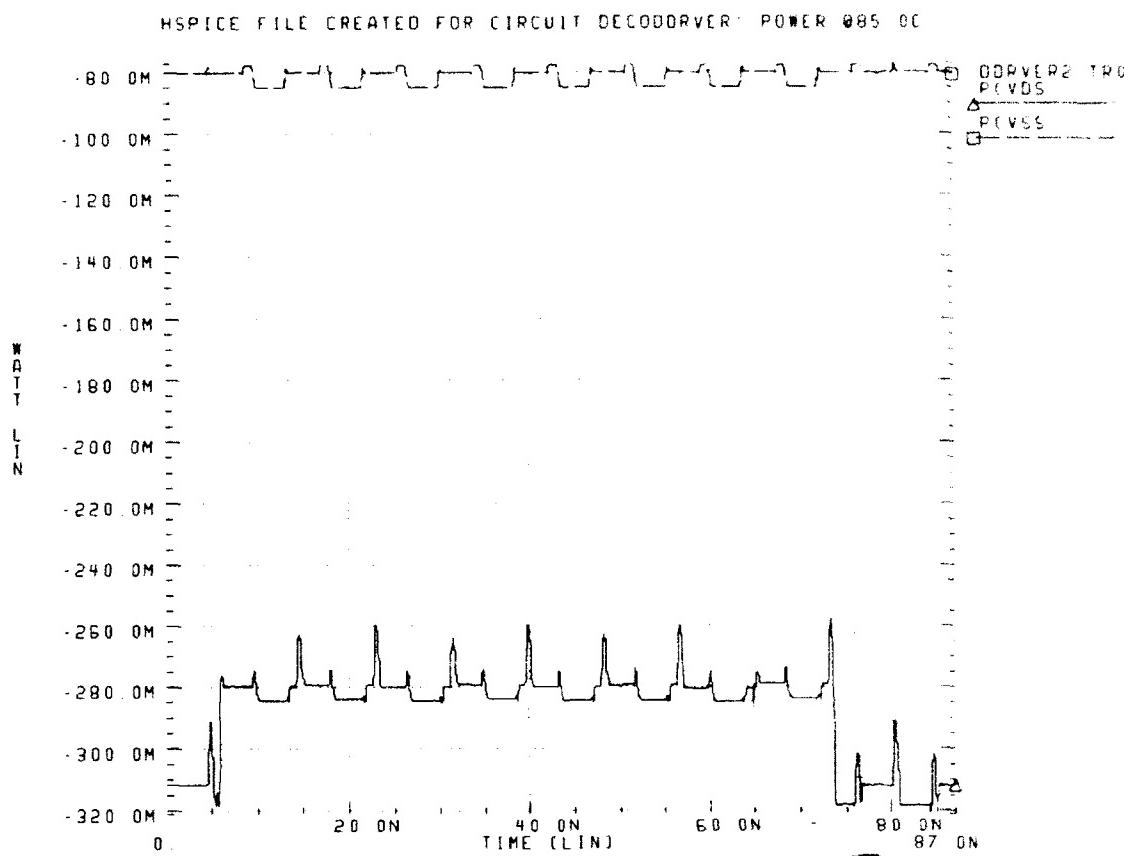


Figure 5.31 DECODDRVER HSPICE POWER at 85.0C

F. Output Logic Circuitry (OUTPUT)

The purpose of the OUTPUT circuit is to use the logical status of the GaAs DRAM memory array bit input-output (BIO) lines coupled with the assertion of either of the control signals, even dummy cell (EDUMMY) or odd dummy cell (ODUMMY), finally coupled with the presence of a READ operation to operate correctly the output data latch assigned to each data bit position. Using the design of the RAM array [Ref. 8], it may be seen that the BIO lines are on the two sides of the differential sense amplifier and are called "EVENBIO" (or EBIO) and "ODDBIO" (or OBIO). Additionally, each BIO line has a "dummy" cell attached to it, the EVENBIO side has a dummy cell, ODUMMY, and the ODDBIO side has a dummy cell, EVENDUMMY. The purpose of these dummy cells, as thoroughly discussed in [Ref. 8], is to provide a known reference voltage for use by the differential sense amplifier. Basically, the voltage placed on the "xBIO" line by the "yDUMMY" cell assists the differential sense amplifier in deciding which way to flip.

Notice also from the work of Vagts, [Ref. 8], the capacitance of the dummy cell is much smaller than the capacitance used by the main storage elements.

The control signals, EDUMMY and ODUMMY, are generated by the circuit DECODDRVER, see Figure 5.23 on page 187. The purpose of these signals is to provide to the OUTPUT circuit the knowledge of which dummy cell is being accessed, regardless of the chosen operation, READ, WRITE, or REFRESH. The knowledge of which dummy cell is being accessed (which indicates to the circuit which BIO line will contain the actual bit data read from the target memory cell), the voltaic status of the GaAs DRAM memory array BIO lines, and the assertion of a READ operation (as asserted through MREAD) are sufficient to easily discern the READ data bit value and cause it to be latched into the output data latch. It is interesting to note that a data latch, not a data flip-flop, was intentionally chosen so that the longest possible time within the target READ operation is allowed for the data lines to settle as the output data latch contents are not latched until the falling edge of the MREAD signal. See Figure 5.32 on page 196 for the OUTPUT schematic and logical equivalence.

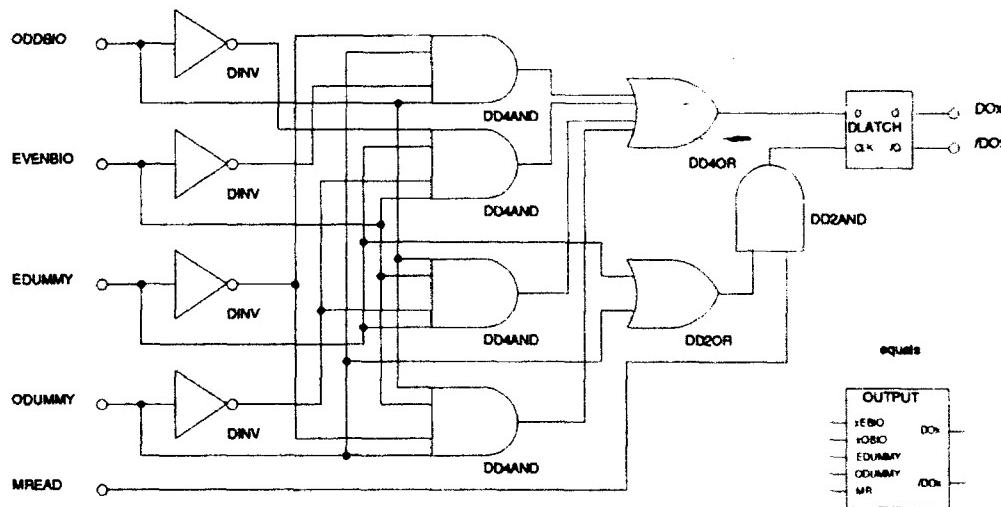


Figure 5.32 OUTPUT Schematic and Logical Equivalence

The OUTPUT circuit transient analysis was executed in much the same way as the previous major circuits. Two simulation runs were accomplished, one at the standard default nominal temperature of 25.0C and the other at the elevated nominal temperature of 85.0C. Additionally, as before, uncluttered figures

depicting the HSPICE simulation transient analysis are shown to facilitate easier understanding of the circuit under test. The first figure of the OUTPUT circuit transient analysis is Figure 5.33 on page 197.

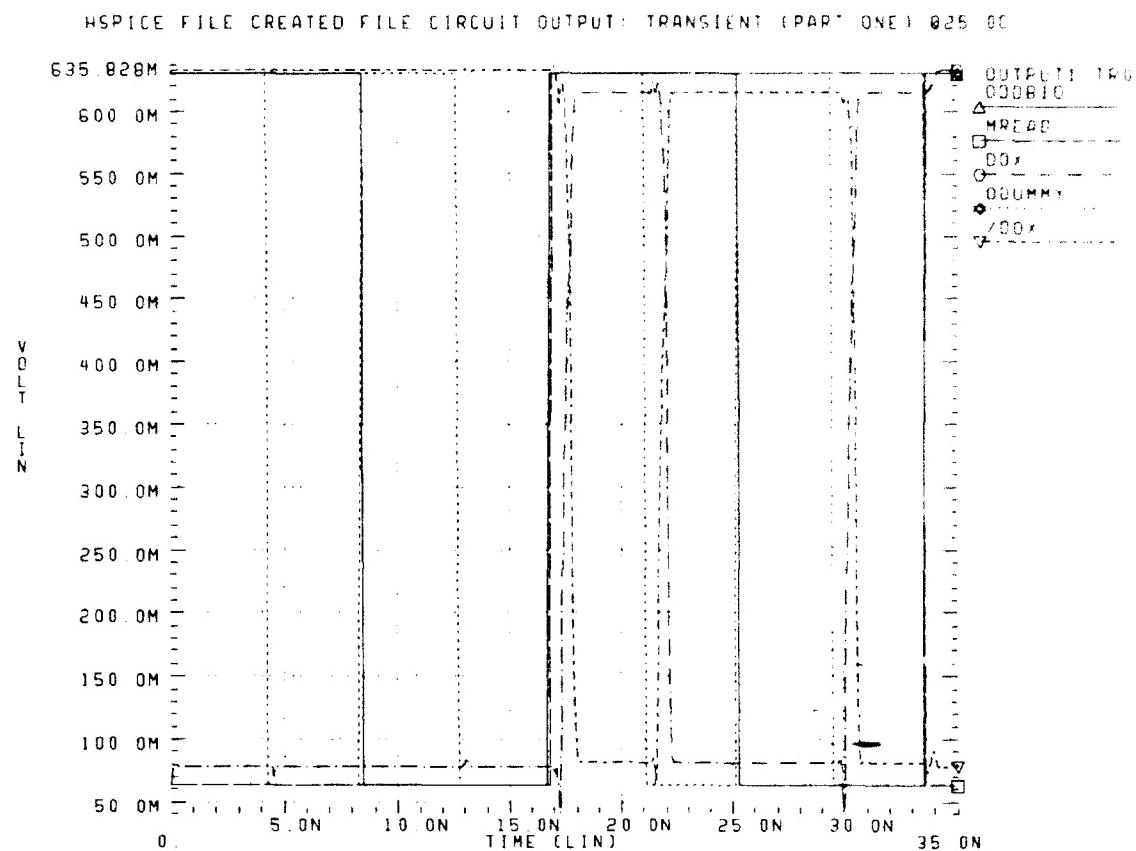


Figure 5.33 OUTPUT HSPICE Transient Analysis (Part One) at 25.0C

This figure, Figure 5.33 on page 197, shows the ODDBIO line from the GaAs DRAM memory array, the MREAD signal, the ODUMMY control signal, and the two output lines from the output data latch, DO_x and /DO_x (Data Out x & /{Data OUT x}). It may be seen in Figure 5.33 on page 197 that the output data latch output lines do not change until the enable signal to the output data latch (MREAD) is asserted, and continue to change until the enable signal to the output data latch (MREAD) is de-asserted. Additionally, it may be seen that once the output data latch is allowed to feel its Data input, the output DO_x goes high because the ODDBIO signal is HIGH and the ODUMMY is high. The combination of the ODDBIO = HIGH and the ODUMMY = HIGH indicates to the OUTPUT logic that a bit data ONE has been read. This transition occurs from ~17 nanoseconds to ~22 nanoseconds. At time ~21 nanoseconds, the ODUMMY goes LOW causing the OUTPUT circuit logic to reconsider its position on the value of the "just read" bit data and the output data

latch goes to LOW at ~22 nanoseconds. The value of the output data latch is finally secured at ~34.5 nanoseconds, when the MREAD signal is de-asserted.

The second figure of the OUTPUT circuit transient analysis is Figure 5.34 on page 198. This figure shows the activities of the MREAD signal, the two output data latch signals, DOx and /DOx, and the EVENBIO and EDUMMY signals. An examination of the associated schematics for the GaAs DRAM memory array and the DECODDRVER will show that the EVENBIO and EDUMMY signals will always be the inverse of the ODDBIO and ODUMMY signals.

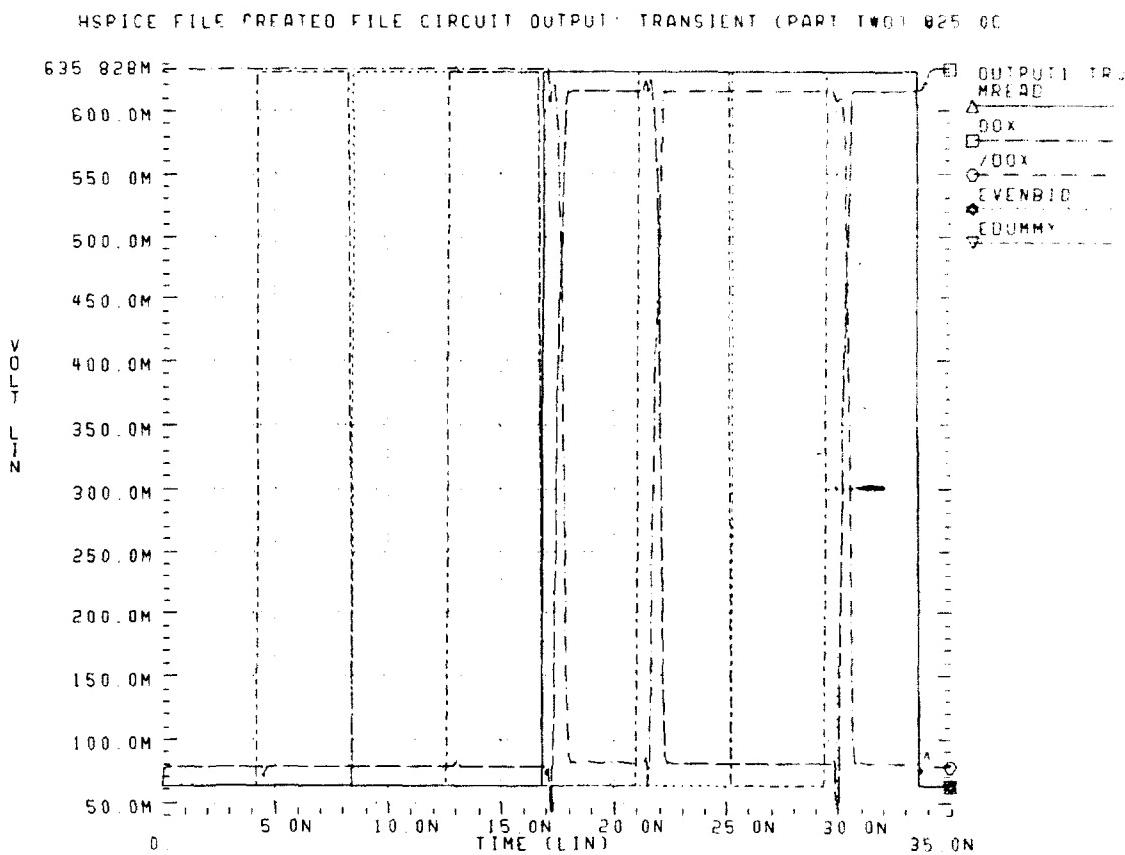


Figure 5.34 OUTPUT HSPICE Transient Analysis (Part Two) at 25.0C

The third and final figure for the nominal temperature HSPICE simulation of the OUTPUT circuit is the power dissipation, see Figure 5.35 on page 199. See "Listing File for OUTPUT Transient Analysis @ 25.0C" of Appendix A on page 357.

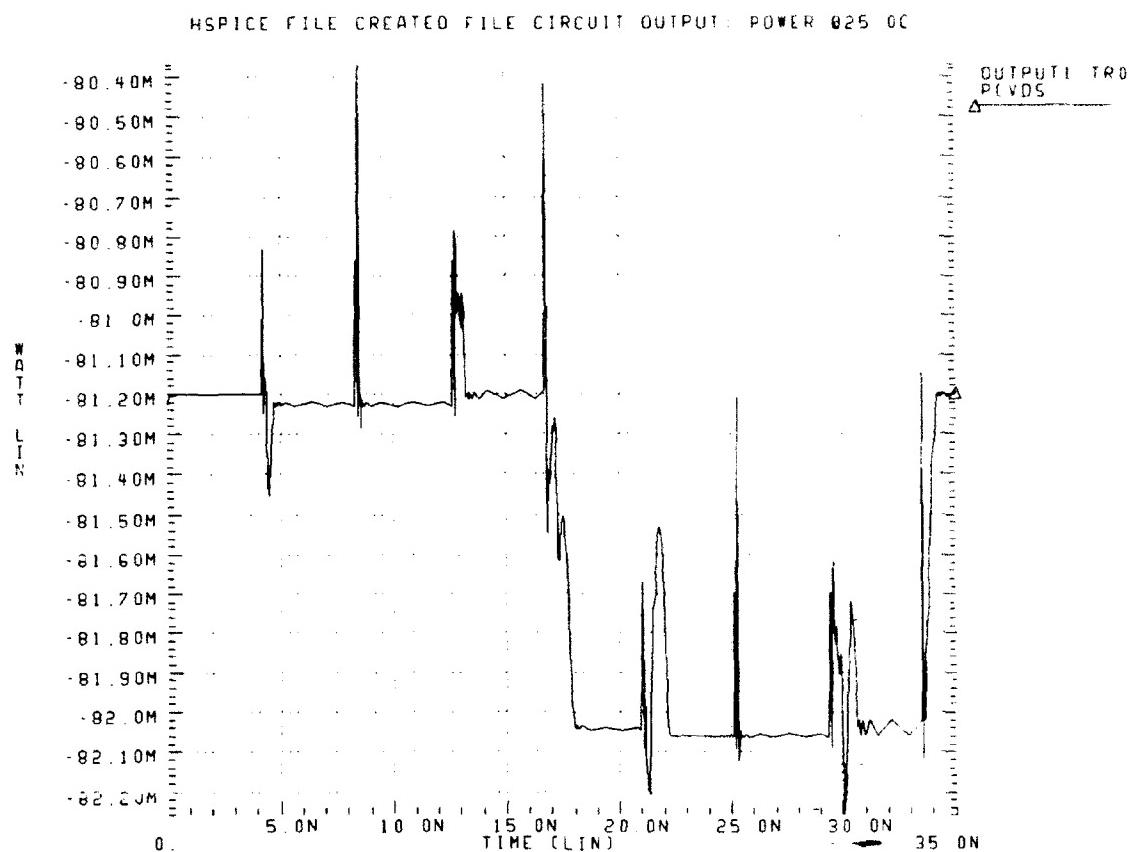


Figure 5.35 OUTPUT HSPICE POWER at 25.0C

The next three figures show the same signals as described previously for the HSPICE simulation of the OUTPUT circuit except the simulation was executed at a nominal temperature of 85.0C, see Figure 5.36 on page 200, Figure 5.37 on page 201, and Figure 5.38 on page 202.

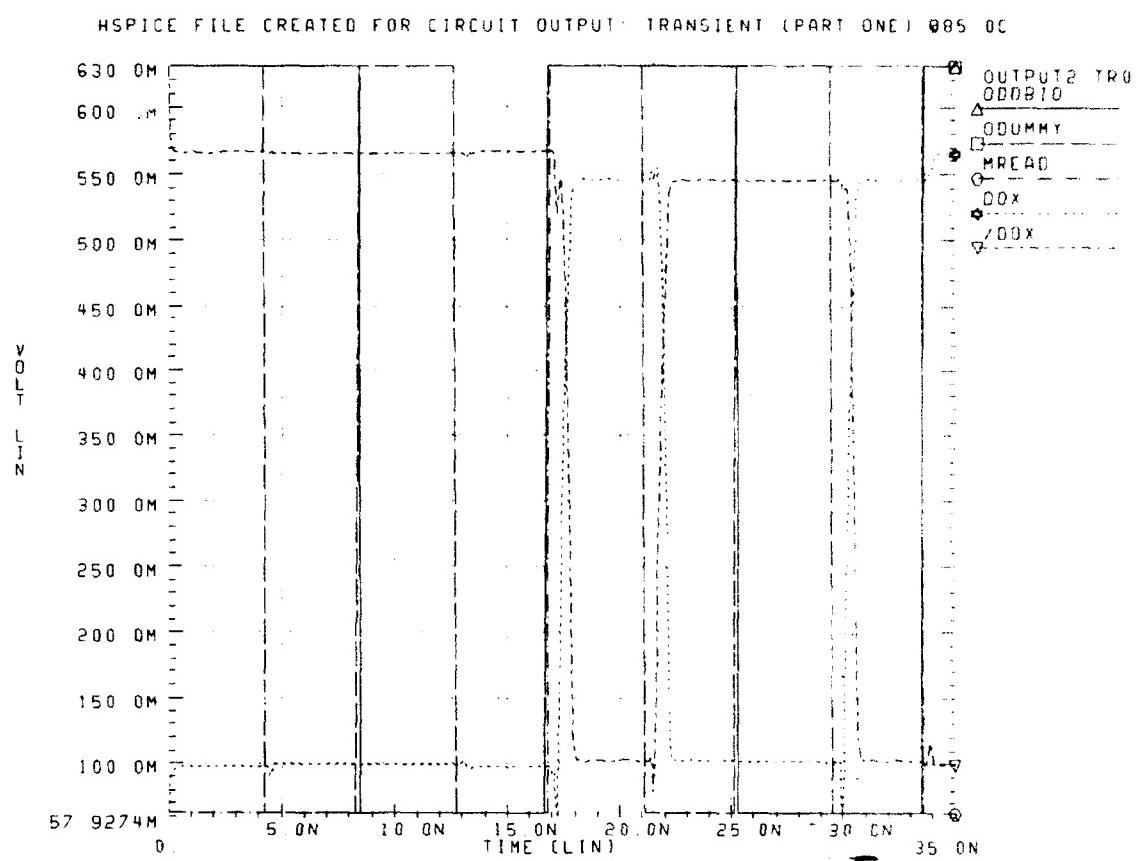


Figure 5.36 OUTPUT HSPICE Transient Analysis (Part One) at 85.0C

HSPICE FILE CREATED FOR CIRCUIT OUTPUT TRANSIENT (PART TWO) 885.0C

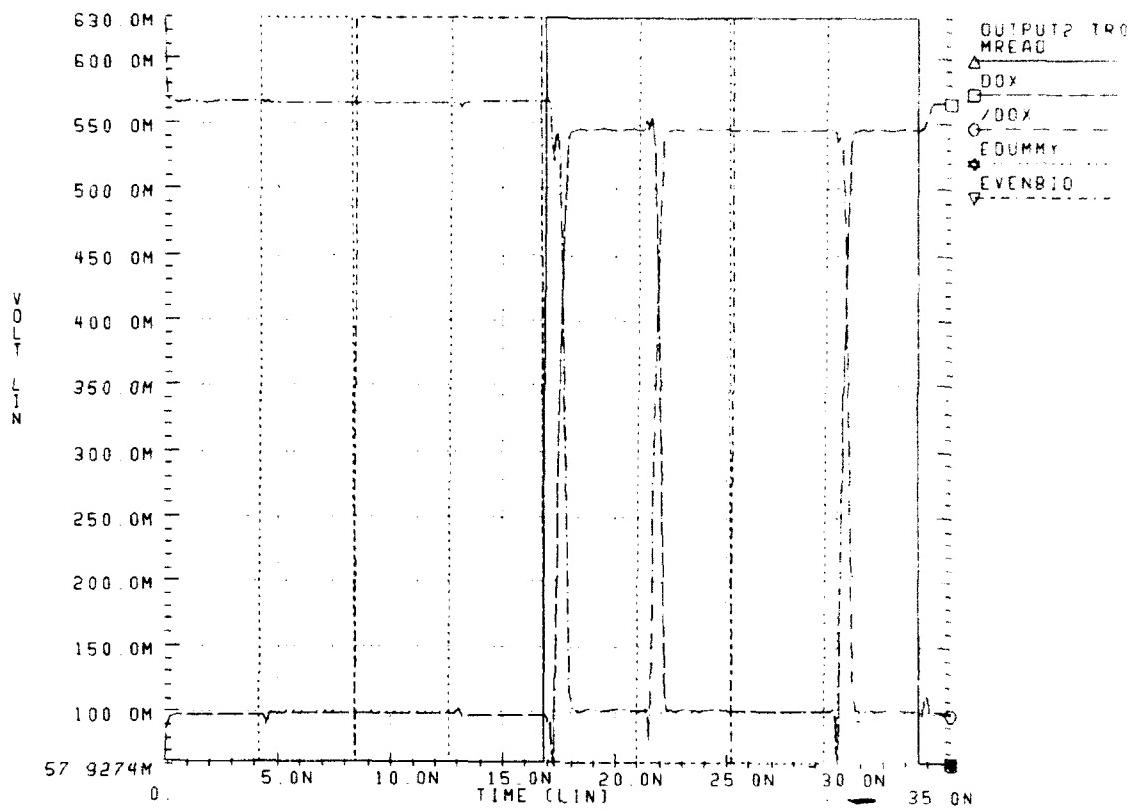


Figure 5.37 OUTPUT HSPICE Transient Analysis (Part Two) at 85.0C

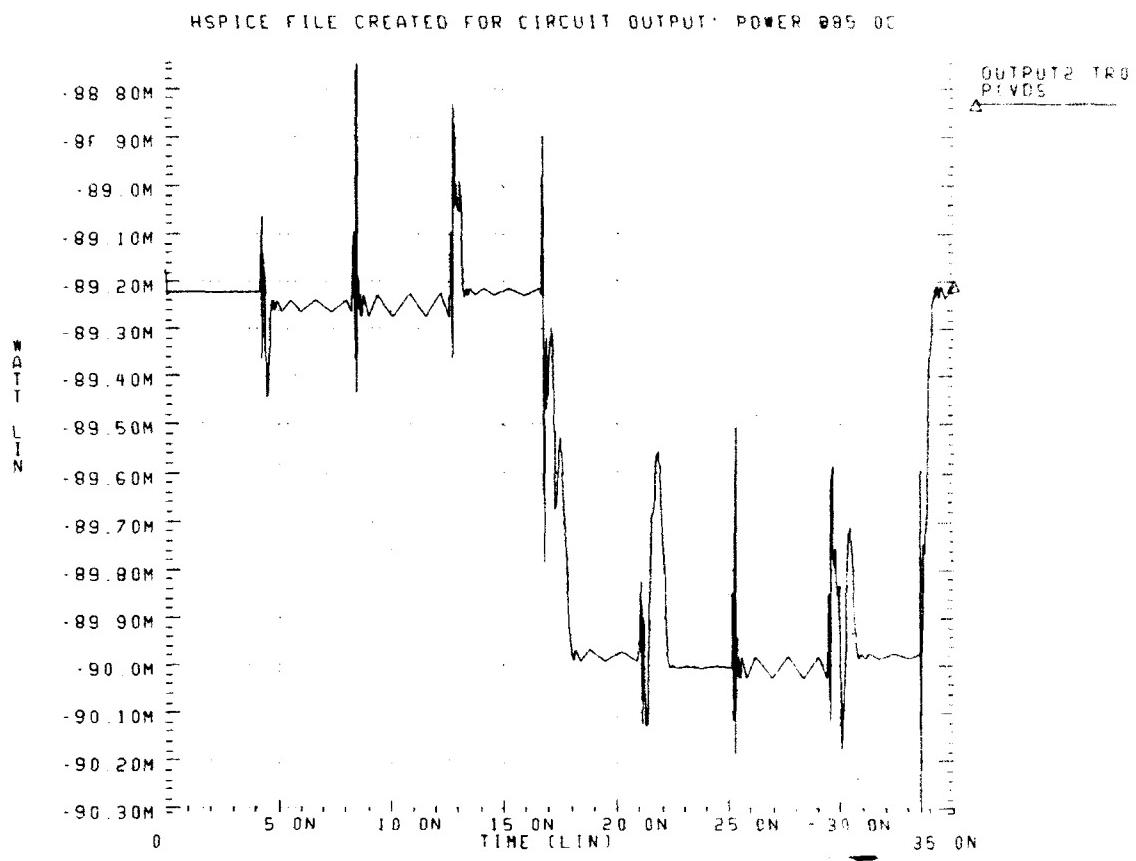


Figure 5.38 OUTPUT HSPICE POWER at 85.0C

G. Operation Priority Logic Circuitry (WRITEP)

The purpose of the operation priority circuit, WRITEP, is to establish the relative priorities amongst the three available GaAs DRAM memory operations, READ, WRITE and REFRESH.

The REFRESH operation was chosen to have the highest priority in order to prevent data spoillage due to refresh latency. The next operation in priority was the WRITE operation. This choice was made to allow the CPU to dump data into the memory using the WRITE operation. It was decided that the READ operation would have the lowest priority. The circuit design is simple and little else needs to be reported with regard to this circuit. See Figure 5.39 on page 203 for the WRITEP schematic and logical equivalence.

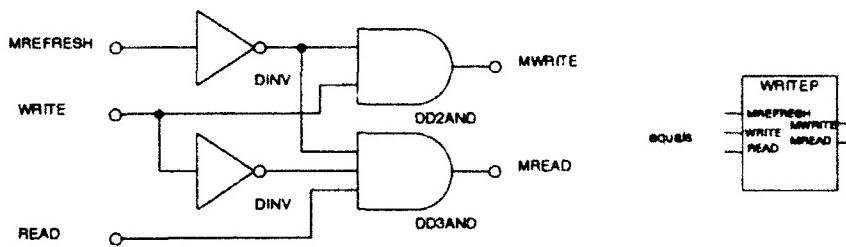


Figure 5.39 WRITEP Schematic and Logical Equivalence

The WRITEP HSPICE transient analysis is shown in Figure 5.40 on page 203. The upper graph of Figure 5.40 shows the three circuit inputs, READ, WRITE, and MREFRESH. The lower graph of Figure 5.40 shows the resultant output signals of MREAD and MWRITE. It may be seen in the lower graph of Figure 5.40 that the MREAD output is only asserted when both MWRITE and MREFRESH are de-asserted.

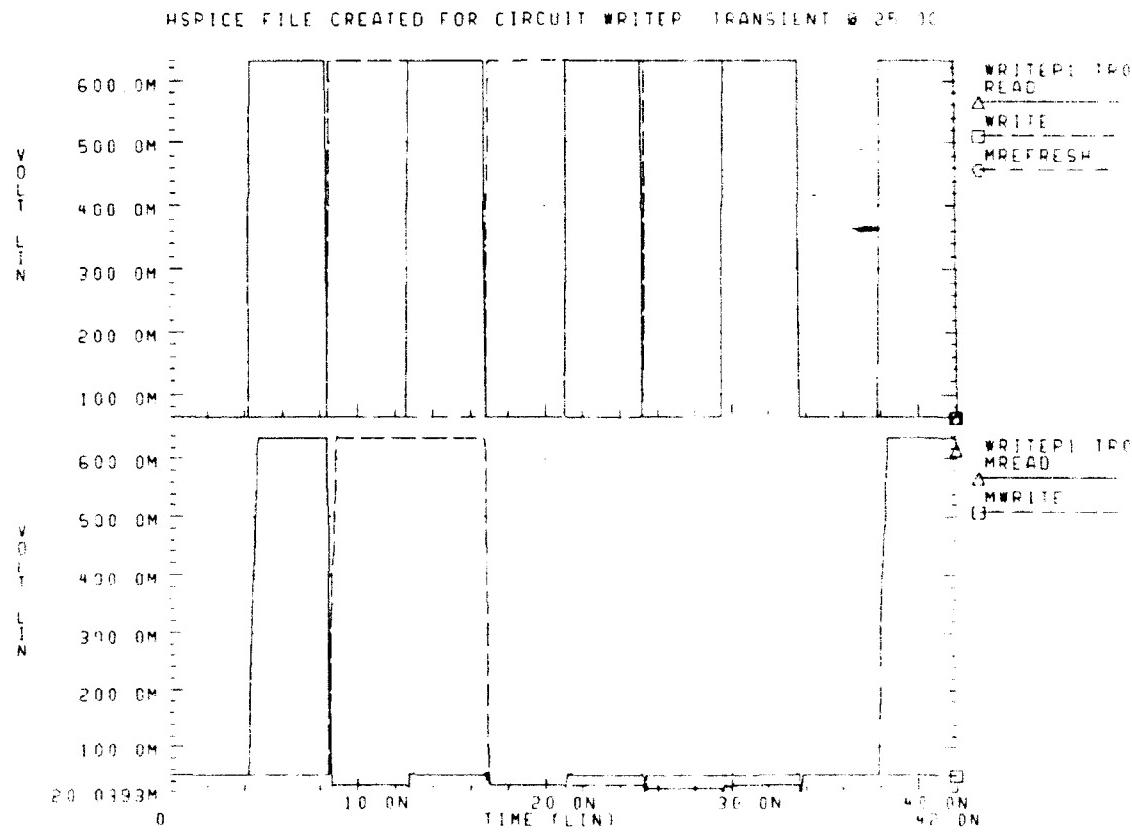


Figure 5.40 WRITEP HSPICE Transient Analysis at 25.0C

The next figure, Figure 5.41 on page 204, shows the power dissipation of the WRITEP circuit operating at a nominal temperature of 25.0C.

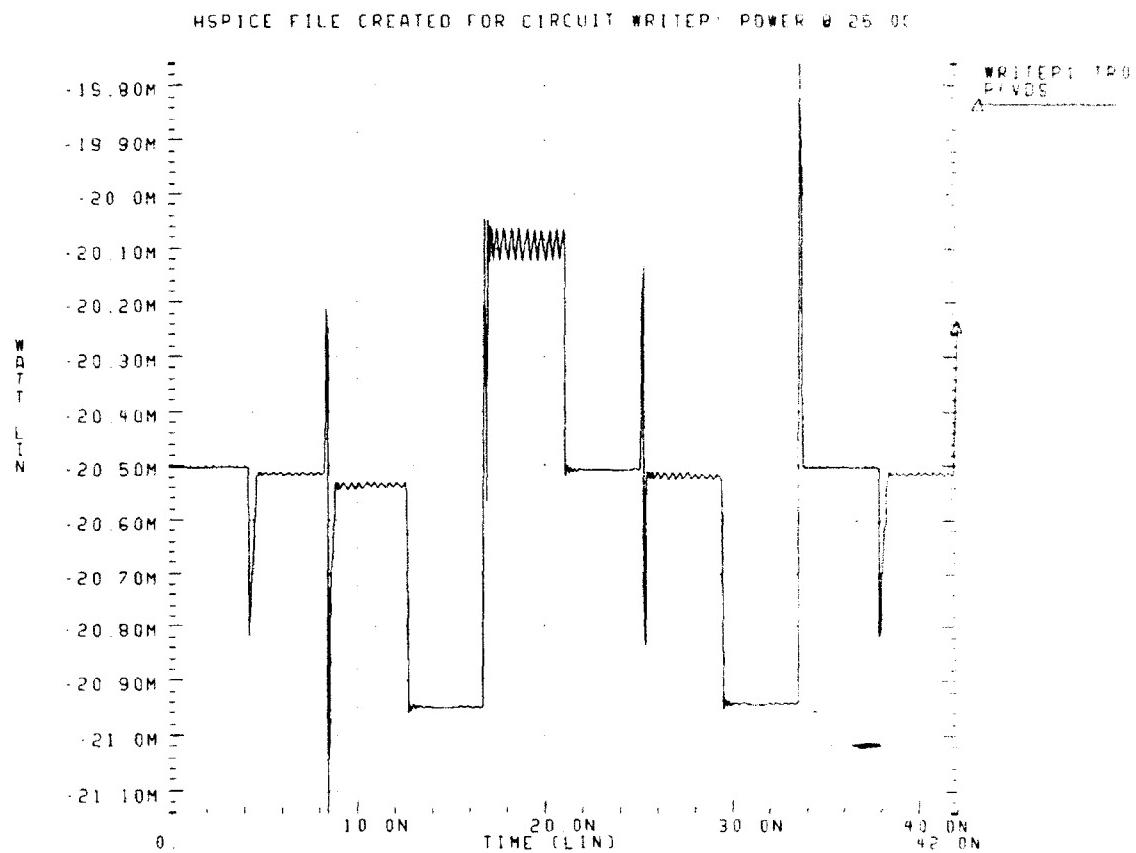


Figure 5.41 WRITEP HSPICE POWER at 25.0C

The final two figures concerning the WRITEP circuit demonstrates the same signals with the circuit operating at a nominal temperature of 85.0C. See Figure 5.42 on page 205 and Figure 5.43 on page 206.

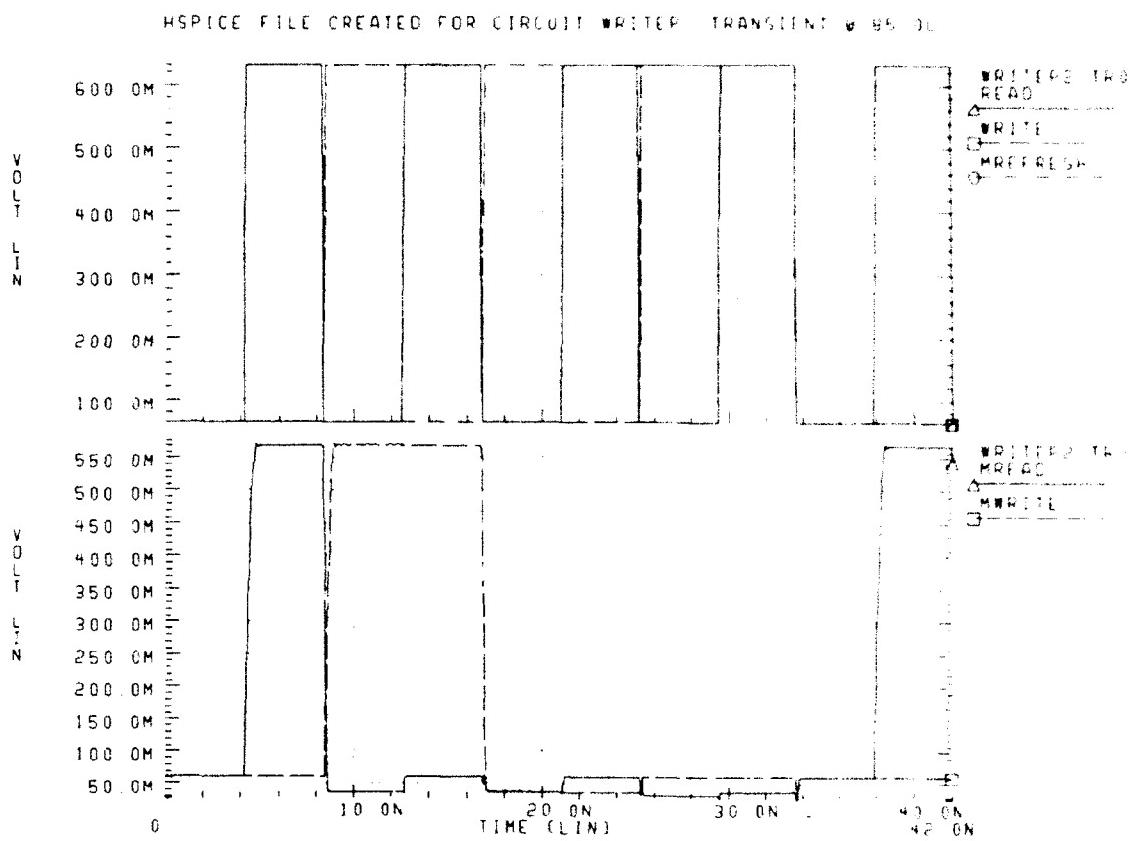


Figure 5.42 WRITERP HSPICE Transient Analysis at 85.0C

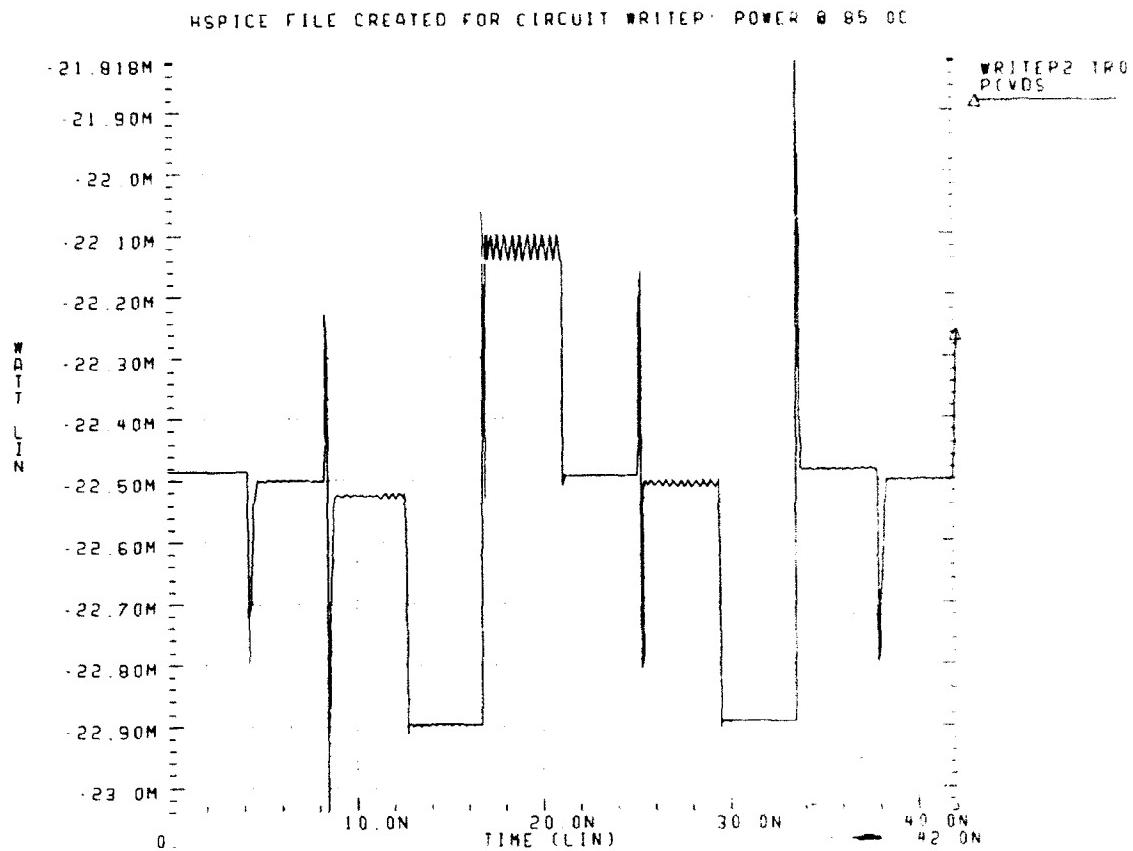


Figure 5.43 WRITEP HSPICE POWER at 85.0C

H. Memory Busy Circuitry (MBSY)

The only reason that this circuit (which consists entirely of one DD3OR gate) is in the major circuits portion of this report is because this circuit occupies a major block of the hierachial block diagram, see Figure 6.1 on page 218.

The operation of this circuit is simple. If any of the three GaAs DRAM memory array operation signals (MREAD, MWRITE, and MREFRESH) are asserted then the memory busy signal (MBSY) is asserted. This control signal, MBSY, is one of the two external control signal outputs of the GaAs DRAM memory array. See Figure 5.44 on page 207 for the MBSY schematic and logical equivalence.



Figure 5.44 MBSY Schematic and Logical Equivalence

The MBSY HSPICE transient analysis and power dissipation graphs are shown in the following two figures. The first figure demonstrates the transient operation (upper graph) and power dissipation (lower graph) of the circuit operating at a nominal temperature of 25.0C. See Figure 5.45 on page 207. See "Listing File for MBSY Transient Analysis @ 25.0C" of Appendix A on page 366.

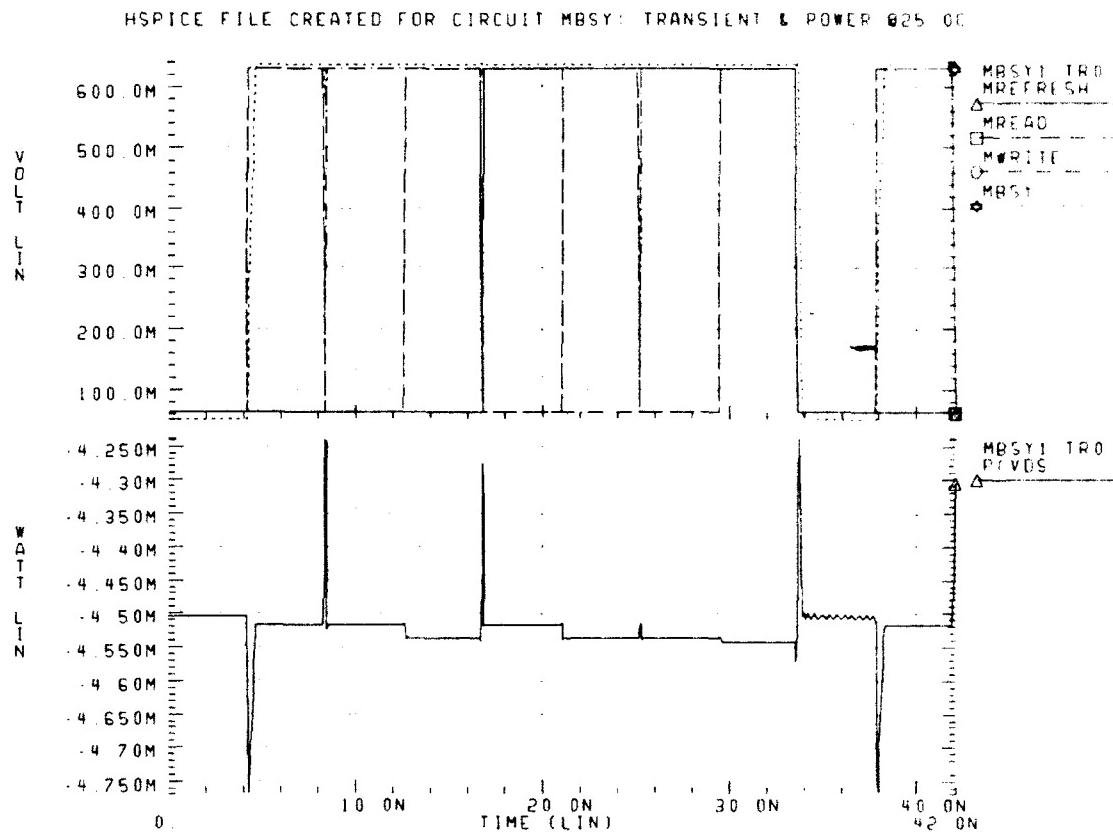


Figure 5.45 MBSY HSPICE Transient Analysis & Power at 25.0C

The next figure demonstrates the transient operation (upper graph) and power dissipation (lower graph) of the DRDY circuit operating at a nominal temperature of 85.0C, see Figure 5.46 on page 208.

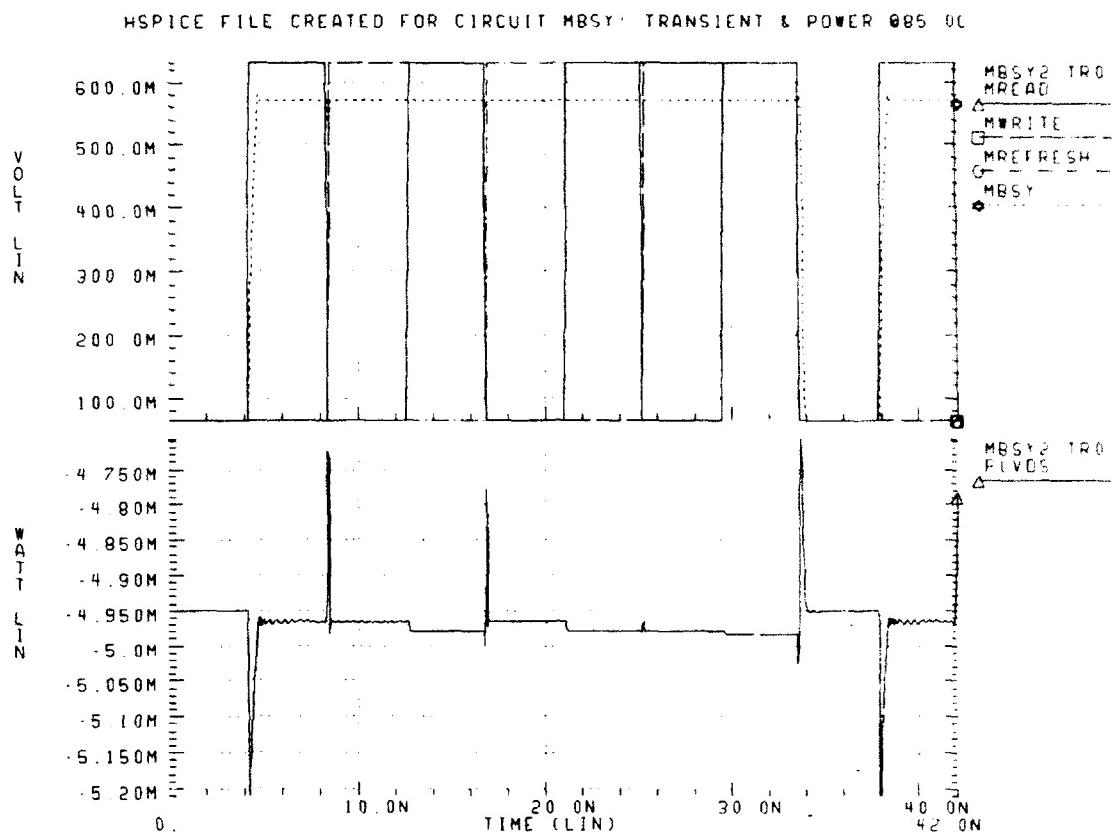


Figure 5.46 MBSY HSPICE Transient Analysis & Power at 85.0C

I. Data Ready Circuitry (DRDY)

This data ready (DRDY) circuit also occupies a major block of the hierarchical block diagram and this is its rationale for being included in the major circuits portion of this report.

The operation of this circuit is simple. The DRDY signal is de-asserted only during the actual operation of the READ cycle. Because of the output data latch, the data from the last READ operation is preserved. See "Output Logic Circuitry (OUTPUT)" on page 195. This control signal, DRDY, is the other external control signal output of the GaAs DRAM memory array. See Figure 5.47 on page 209 for the DRDY schematic and logical equivalence.

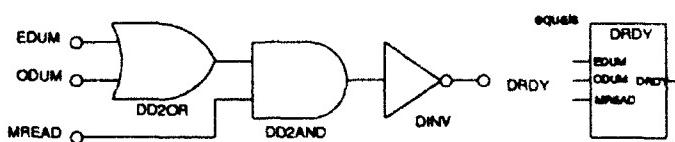


Figure 5.47 DRDY Schematic and Logical Equivalence

The DRDY HSPICE transient analysis and power dissipation graphs are shown in the following two figures. The first figure demonstrates the transient operation (upper graph) and power dissipation (lower graph) of the circuit operating at a nominal temperature of 25.0C, see Figure 5.48 on page 209. See "Listing File for DRDY Transient Analysis @ 25.0C" of Appendix A on page 370.

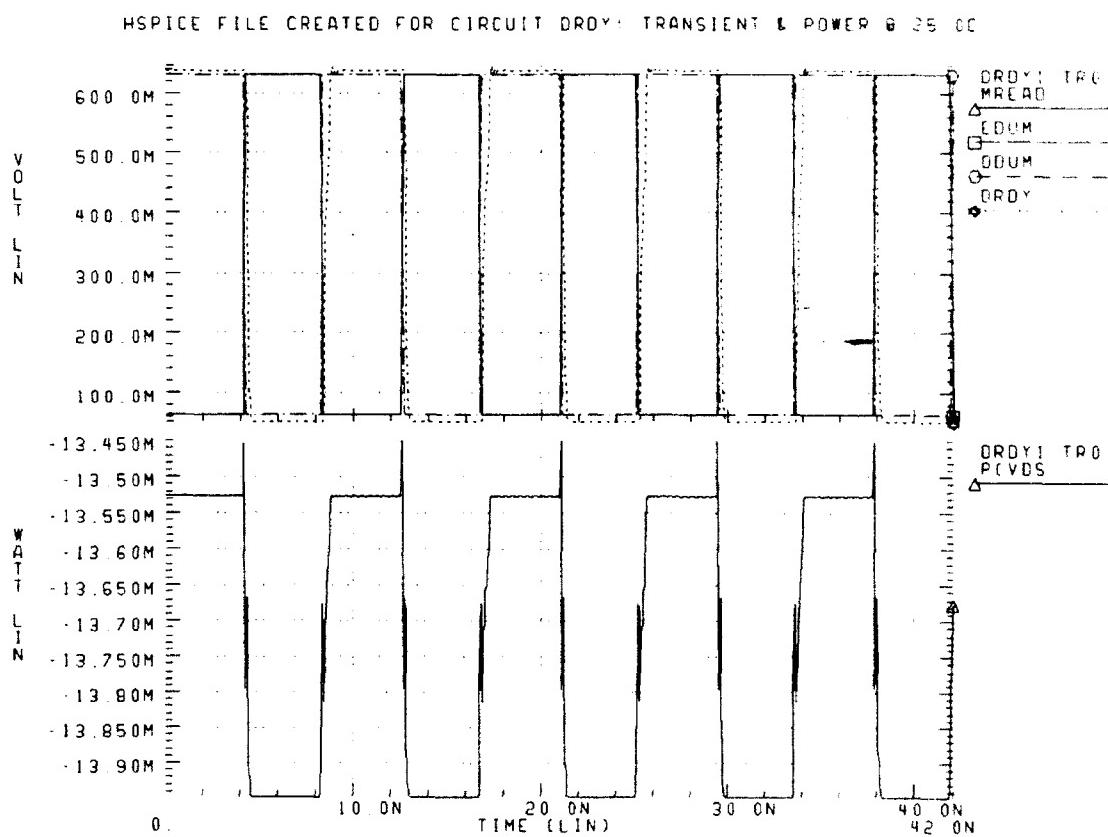


Figure 5.48 DRDY HSPICE Transient Analysis & Power at 25.0C

The next figure demonstrates the transient operation (upper graph) and power dissipation (lower graph) of the DRDY circuit operating at a nominal temperature of 85.0C, see Figure 5.49 on page 210.

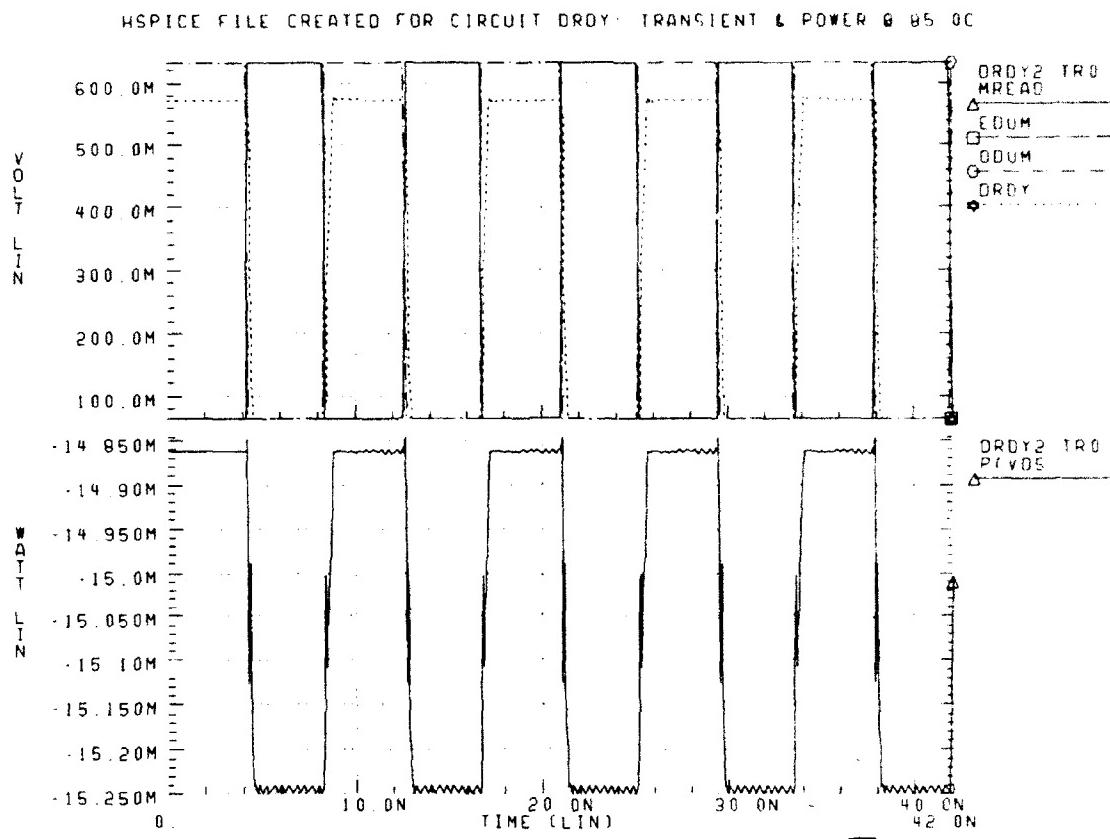


Figure 5.49 DRDY HSPICE Transient Analysis & Power at 85.0C

J. Write Logic Circuitry (WLOGIC)

The purpose of the write logic (WLOGIC) circuitry is to use the combination of input and control signals, Dx (data bit x), A0 (address bit zero), DAS (data strobe), MWRITE (master write), and PH2 (phase two of the GaAs DRAM clock) to control the actions of the pull-up and pull-down transistors attached to both BIO (bit I/O lines) to force the BIO lines to the correct voltage state at the WRITE (!) time. This is accomplished quite simply as seen in the following figure, see Figure 5.50 on page 211.

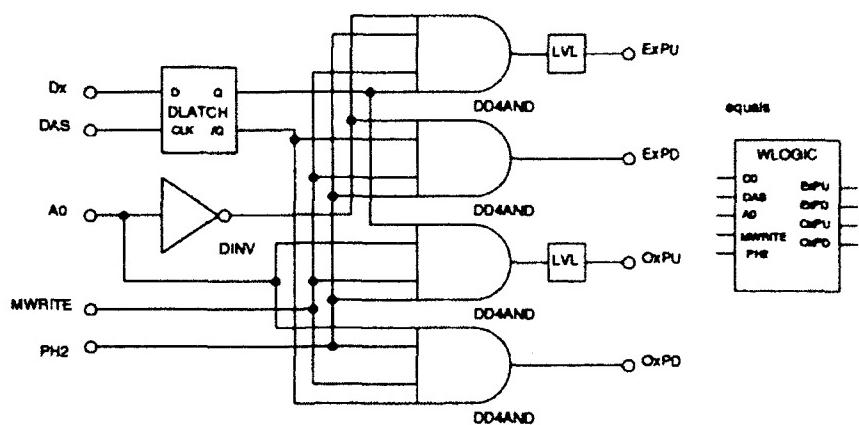


Figure 5.50 WLOGIC Schematic and Logical Equivalence

Examining Figure 5.50, it is seen that first the input data bit (D_x) is latched in the DLATCH by the de-assertion of the input control signal, data strobe (DAS). The master write signal (MWRITE) is then used along with the input address bit zero (A0) combined with the phase two signal of the CLOCK to enable one of the four DD4AND gates shown in Figure 5.50. Referring to [Ref. 8:p. 13], one may see that there are four GaAs MESFET driving transistors connected to the BIO lines of each memory array. These transistors, even side BIO bit x pull-up (ExPU), even side BIO bit x pull-down (ExPD), odd side BIO bit x pull-up (OxPU), and odd side BIO bit x pull-down (OxPD), serve to drive the appropriate BIO line to the correct data voltage level during a MWRITE cycle so that this appropriate data voltage level is then felt by the associated parallel plate capacitor through the associated access MESFET. Obviously, the circuit should only force the BIO line to the data value during a MWRITE cycle. Less obviously, this portion of the MWRITE cycle occurs during PH2 of the clock.

It is interesting to note that the input data bit may be latched at any time, that is falling edge DAS is the latching signal. Of course, if the input data bit is changed at an inappropriate time, it may cause the MWRITE operation to fail. The level shifters (LVL) associated with the ExPU and OxPU outputs are necessary because the associated driving MESFETs are depletion mode.

The WLOGIC HSPICE transient analysis and power dissipation graphs are shown in the following two figures. The first figure demonstrates the transient operation, input signals, (upper graph), transient operation, output signals (middle graph), and power dissipation (lower graph) of the circuit operating at a nominal temperature of 25.0C, see Figure 5.51 on page 212. See "Listing File for WLOGIC Transient Analysis @ 25.0C" of Appendix A on page 373.

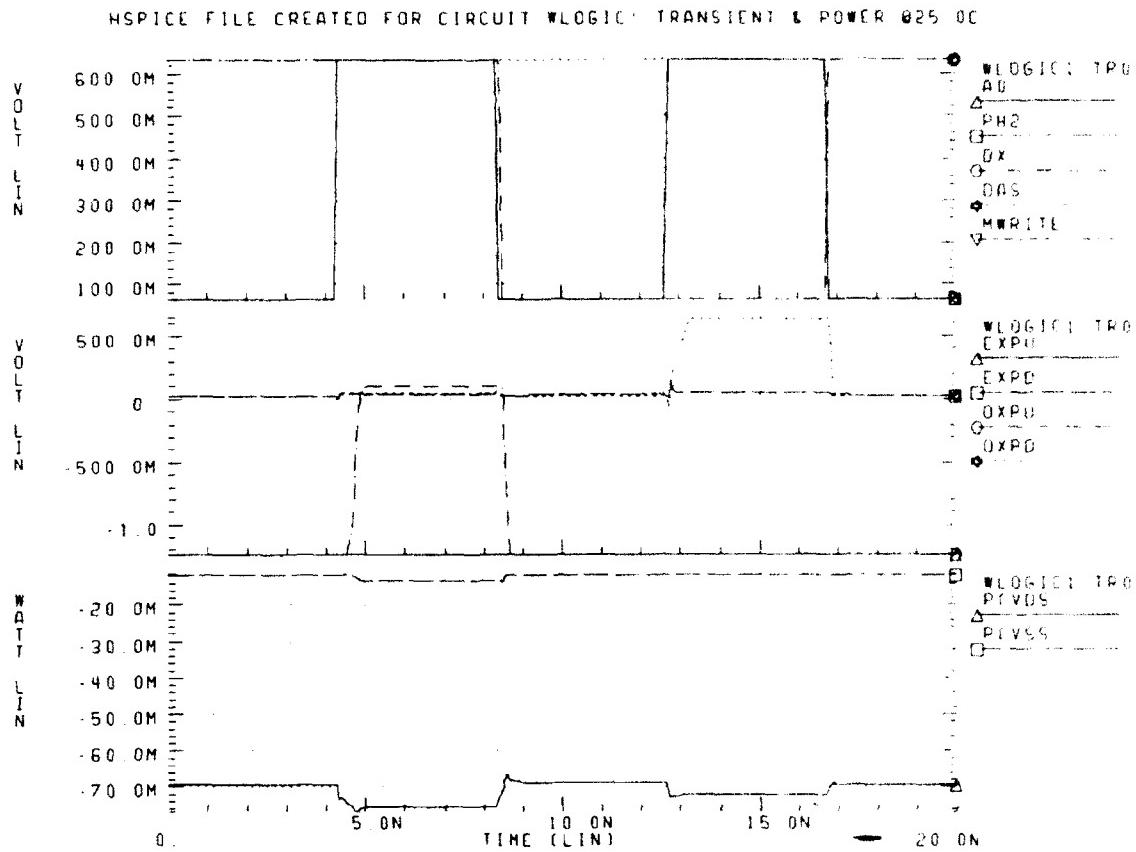


Figure 5.51 WLOGIC HSPICE Transient Analysis & Power at 25.0C

The second part of the WLOGIC HSPICE transient analysis and power dissipation graphs are shown in the following figure. This figure demonstrates the transient operation input signals. (upper graph), transient operation output signals (middle graph), and power dissipation (lower graph) of the circuit operating at a nominal temperature of 85.0C, see Figure 5.52 on page 213.

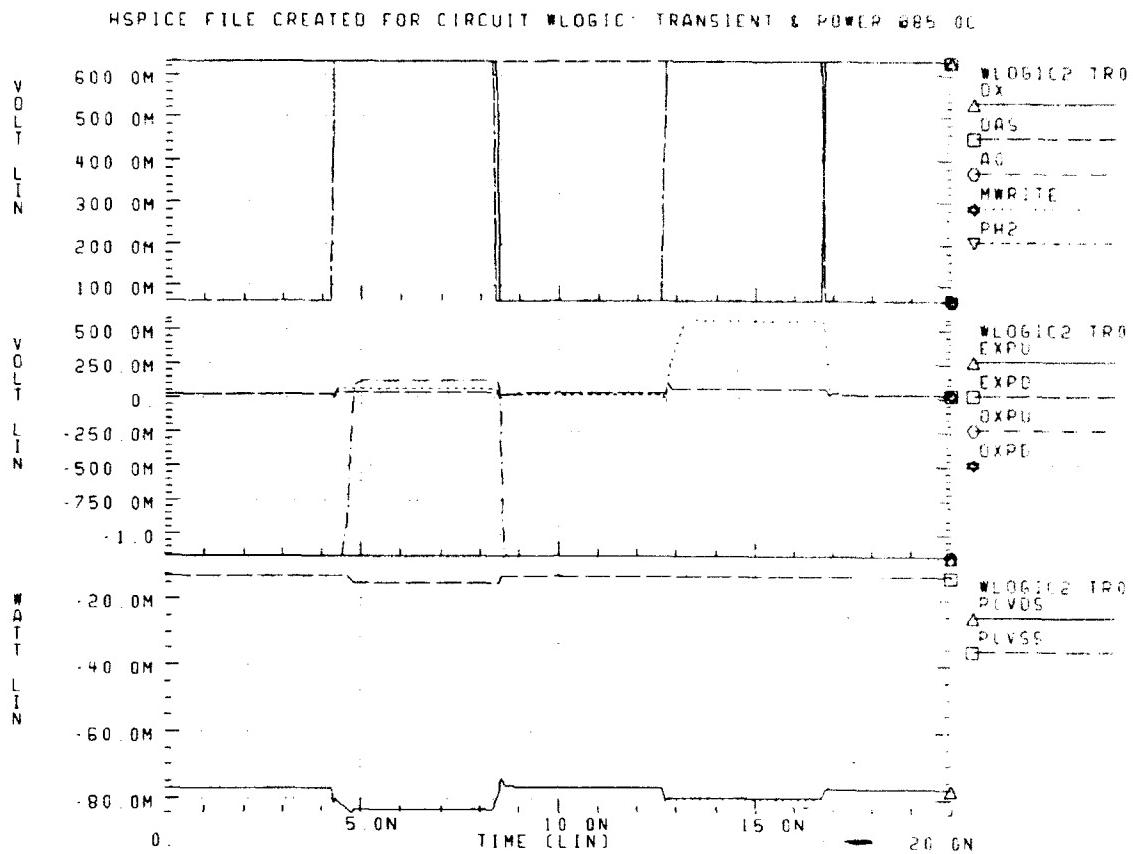
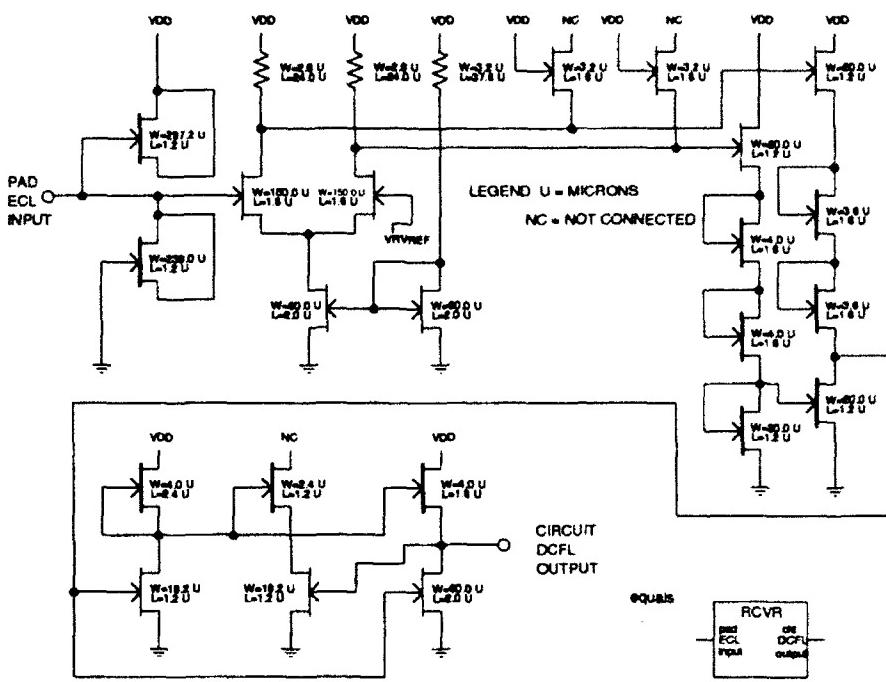


Figure 5.52 WLOGIC HSPICE Transient Analysis & Power at 85.0C

K. Pad Receiver Circuit (PADRCVR)

The pad receiver circuit was provided by Vitesse through MOSIS and further modified by S. Long of UCSB. The purpose of this circuit is to receive a ECL signal through the pad as input, convert it to DCFL and output to the main circuit. As this circuit is not original, the HSPICE transient analysis results are not provided and its correct operation will be validated by the demonstration of the GaAs DRAM in its pad-to-pad HSPICE simulation. For the purpose of completeness, the schematic and logical equivalence for the PADRCVR circuit is shown in Figure 5.53 on page 214.



NOTE 1: Resistors constructed of Active Area GaAs Material

Figure 5.53 PADRCVR Schematic and Logical Equivalence

L. Driver Pad Circuit (DRVRPAD)

The driver pad circuit was provided by Vitesse through MOSIS and further modified by S. Long of UCSB. The purpose of this circuit is to receive a DCFL signal from the main circuit as input, convert it to ECL and output it through the pad off-chip. As this circuit is not original, the HSPICE transient analysis results are not provided and its correct operation will be validated by the demonstration of the GaAs DRAM in its pad-to-pad HSPICE simulation. For the purpose of completeness, the schematic and logical equivalence for the DRVRPAD circuit is shown in Figure 5.54 on page 215.

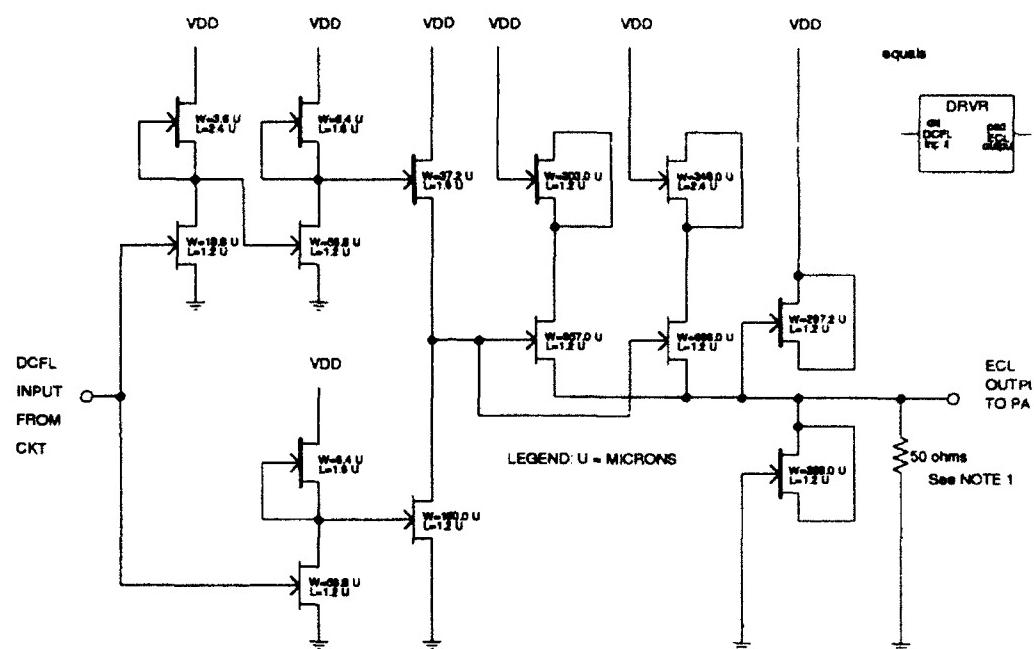


Figure 5.54 DRVRPAD Schematic and Logical Equivalence

M. GaAs DRAM Array (RAM_ARRAY)

The last major circuit to be mentioned in this chapter is the center point of the work by Vagts [Ref. 8]. This circuit is the GaAs DRAM array (RAM_ARRAY). This report will offer only a block diagram of this circuit and will demonstrate its transient analysis in the next chapter as part of the complete design. See Figure 5.55 on page 216 for the GaAs DRAM array as coupled with the circuits OUTPUT and WLOGIC.

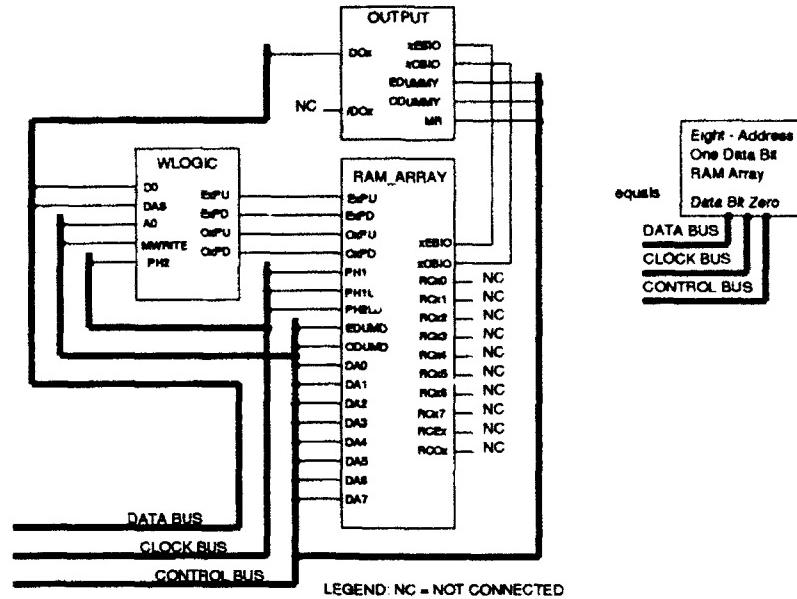


Figure 5.55 RAM_ARRAY Block Diagram

TABLE 5.1 GaAs DRAM HIGH-LEVEL CIRCUITS OPERATING CHARACTERISTICS

Circuit Name	t_{PHL} (ps)	t_{PLH} (ps)	t_{RISE} (ps)	t_{FALL} (ps)	t_{DELAY} (ps)	Avg pwr (watts)
CLOCK @25.0C	727	390	142	765	713	0.315
CLOCK @85.0C	663	353	128	845	656	0.320
DECODER @25.0C	326	555	286	204	555	0.125
DECODER @85.0C	287	542	373	287	542	0.127
COUNTER @25.0C	1117	500	655	254	1114	0.276
COUNTER @85.0C	1091	468	562	285	1049	0.302
DREFRESH @25.0C	1205	1044	355	132	1006	0.437

TABLE 5.1 GaAs DRAM HIGH-LEVEL CIRCUITS OPERATING CHARACTERISTICS

Circuit Name	t_{PHL} (ps)	t_{PLH} (ps)	t_{RISE} (ps)	t_{FALL} (ps)	t_{DELAY} (ps)	Avg pwr (watts)
DREFRESH @85.0C	1145	975	313	160	951	0.475
DECODEDRVER @25.0C	1280	1018	505	236	1281	0.271
DECODEDRVER @85.0C	1291	984	431	275	1275	0.288
OUTPUT @25.0C	1044	585	541	389	575	0.082
OUTPUT @85.0C	1029	571	510	454	593	0.090
WRITEP @25.0C	128	143	394	163	130	0.021
WRITEP @85.0C	127	139	393	173	146	0.023
MBSY @25.0C	222	120	350	138	116	0.005
MBSY @85.0C	221	112	368	166	123	0.005
DRDY @25.0C	201	179	356	139	171	0.014
DRDY @85.0C	208	153	324	157	173	0.015
WLOGIC @25.0C	85	242	426	89	483	0.071
WLOGIC @85.0C	75	228	417	93	444	0.079

VI. GALLIUM ARSENIDE DRAM

This chapter will present the operation and validation of the GaAs DRAM design. Such topics as the overall logic block diagram, layout block diagram, timing for each memory operation, and pad to pad simulation results will be discussed and supporting figures will be provided. Additionally, at the end of this chapter, there is a section which summarizes the characteristics of these memory operations.

A. Overall Block Diagram

The following figure is the overall block diagram of the GaAs DRAM memory, see Figure 6.1 on page 218.

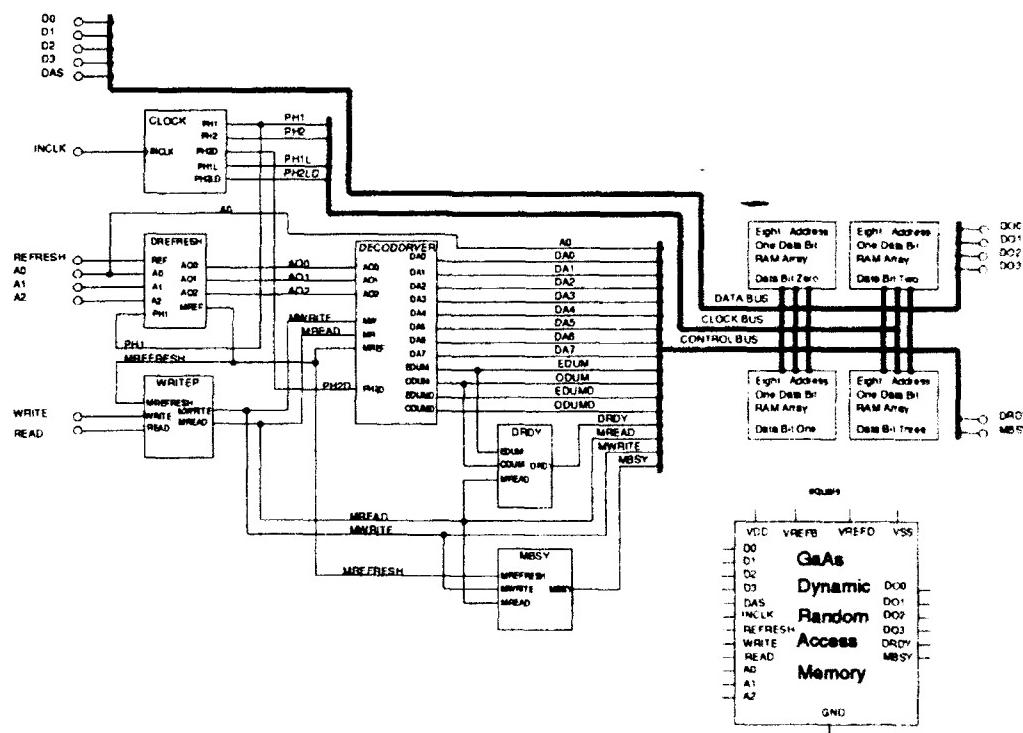


Figure 6.1 GaAs DRAM Overall Logic Block Diagram

This overall block diagram shows the 12 external inputs and the six external outputs. Each block of the block diagram was previously discussed in Chapter 5. The next figure shows the layout block diagram, see Figure 6.2 on page 219.

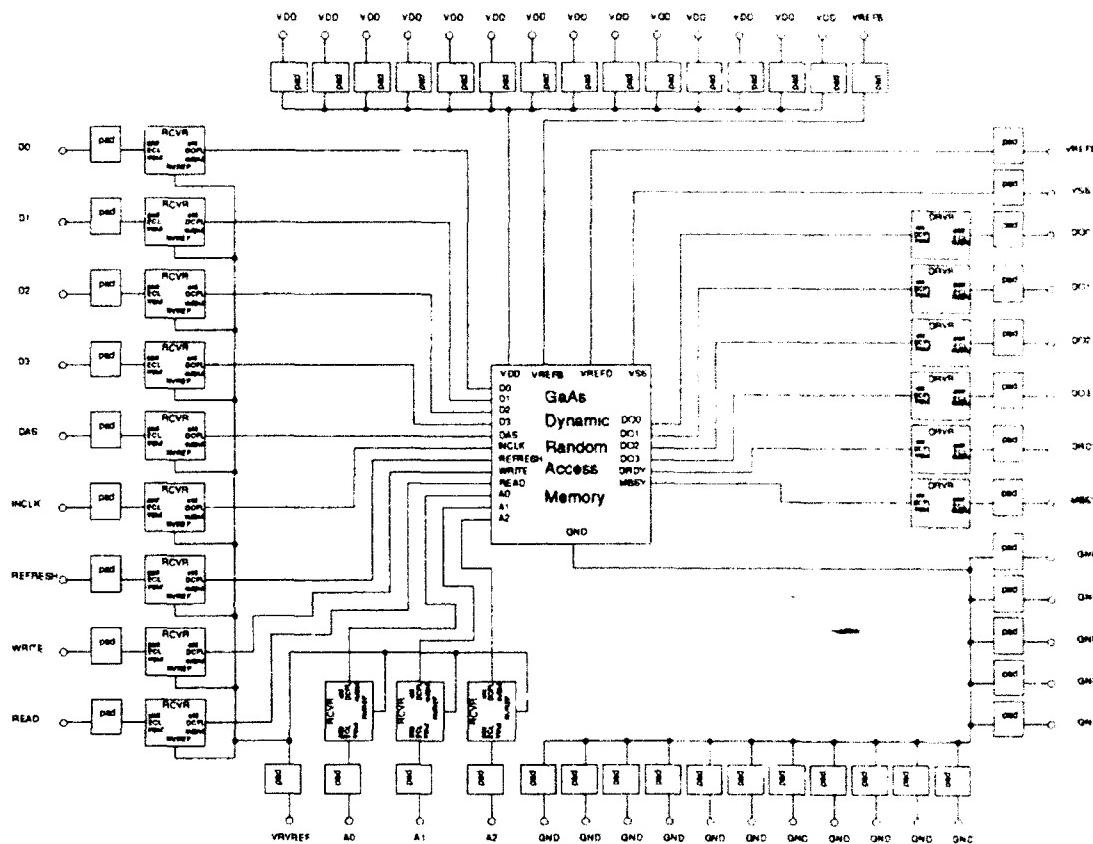


Figure 6.2 GaAs DRAM Layout Block Diagram

B. Layout Block Diagram

Figure 6.2 shows the layout block diagram with all 52 I/O pads. While the actual layout has the various power and ground pads (connections) distributed nearly evenly around the chip, this figure has these pads grouped to facilitate easier understanding. There are maximum current limitations per pad. For both the ground and the main power supply (V_{DD}), the current path and the return current path for the entire design must be distributed over a sufficient number of pads. The actual maximum current values per pad are provided

by the fabrication facility and this information is likely to be considered proprietary. The power consumption testing of the entire design yielded figures which dictated the assignment of 14 pads for V_{DD} , 16 pads for GND, one pad for each of the other various necessary power supplies: VREFB, VREFD, V_{SS} , and VRVREF. The power supply VRVREF is used only to provide a reference voltage for the pad receivers, see Figure 5.53 on page 214. The purpose of the reference voltages VREFB and VREFD are discussed in the work by Vagts [Ref. 8:p. 14], these two power supplies are used in the operation of the GaAs Dynamic RAM_ARRAY. The power supply, V_{SS} , is used by the level shifter (LVL) circuits, see Figure 4.166 on page 154.

One may also notice from both of the block diagrams, Figure 6.1 and Figure 6.2, the inputs and outputs. The next two subsections will discuss each input and output. It should be mentioned again that the external signals, inputs and outputs, are at ECL levels, which equate to a positive logic LOW = 0.4 volts and a positive logic HIGH = 1.1 volts. These ECL levels are used because the vendor supplied pad drivers and pad receivers are designed specifically for ECL logic levels, see Figure 5.53 on page 214 and Figure 5.54 on page 215.

1. INPUTS

Data Bits (D3 - D0): These data inputs are level asserted signals, latched inside the WLOGIC circuitry.

Data Strobe (DAS): This level asserted control signal informs the input data latches (in the WLOGIC circuitry) that the input data bits are present and stable on the input data lines.

Address Bits (A2 - A0): These address data inputs are level asserted, non-latched signals applied to the DECODDRVR circuitry.

Clock (INCLK): This input control signal provides the basic timing reference to the two-phase, non-overlapping CLOCK circuitry.

Refresh (REFRESH): This pulse asserted input control signal, latched by the DREFRESH circuitry, dictates the start timing of the necessary GaAs DRAM refresh operation.

Write (WRITE): This level asserted, non-latched, input control signal indicates the request for a GaAs DRAM write operation. It is applied to the operation priority (WRITEP) circuitry.

Read (READ): This level asserted, non-latched, input control signal indicates the request for a GaAs DRAM read operation. It is applied to the operation priority (WRITEP) circuitry.

2. OUTPUTS

Data Bits (DO3 - DO0): These data outputs are level asserted, latched signals which originate in the output logic (OUTPUT) circuitry.

Memory Busy (MBSY): This level asserted, non-latched, control signal originates in the memory busy (MBSY) circuitry. It indicates that the GaAs DRAM is busy with a read, write, or refresh operation.

Data Ready (DRDY): This level asserted, non-latched, control signal originates in the data ready (DRDY) circuitry. It indicates that the data fetched during the most recently requested read operation is available on the output data lines.

C. Timing and Pad->Pad Simulation

This section will discuss and demonstrate each of the three GaAs DRAM memory operations, WRITE, READ, and REFRESH. It should be mentioned that for the HSPICE execution of the GaAs DRAM pad to pad simulation, the ".options FAST" was used. This HSPICE option, FAST, results in a less stringent set of accuracy requirements for each HSPICE nodal iteration. Use of the FAST option causes a tremendous decrease in simulation time at the price of reduced accuracy for the results. It was decided that because a pad to pad simulation verifies overall design integrity, it was acceptable for use. As a side-bar, without the use of the FAST option, the required pad to pad simulation time (also using the ".option probe" which restricts the output data file to a maximum number of 32 nodes) executing on the SUN SPARCstation 2, was at least two weeks for a transient analysis of 60ns. Additionally, as a result of the less accurate FAST option, the graphs presented in this chapter in validation of the design of the GaAs DRAM are somewhat "choppy".

The HSPICE pad-pad simulation listing files are included in the listing files appendix for each execution. However, in order to reduce to overall size of the appendix, the second and further listing files for the HSPICE pad to pad simulation of the GaAs DRAM will have the multiple pages of identical HSPICE file data removed, leaving only the unique file data for each simulation run. See "GaAs DRAM HSPICE Pad->Pad Simulation" on page 379.

1. WRITE OPERATION

This section will discuss and demonstrate the execution of a GaAs DRAM WRITE operation. As a reminder, the external inputs and outputs are at ECL logic levels. The first graph, see Figure 6.3 on page 222, has two panels. The first (upper) panel shows the address input signals, A2 - A0, and the data strobe, DAS, signal. The input address bits are set to equal address five and the data strobe signal is set to a level logic HIGH. The second (lower) panel shows the data input signals, D3 - D0. These are set to equal 1101 in binary with MSB first, that is, D3=1, D2=1, D1=0, and D0=1.

HSPICE PAD → PAD SIMULATION OF GAAS DRAM : WRITE OPERATION (PART ONE)

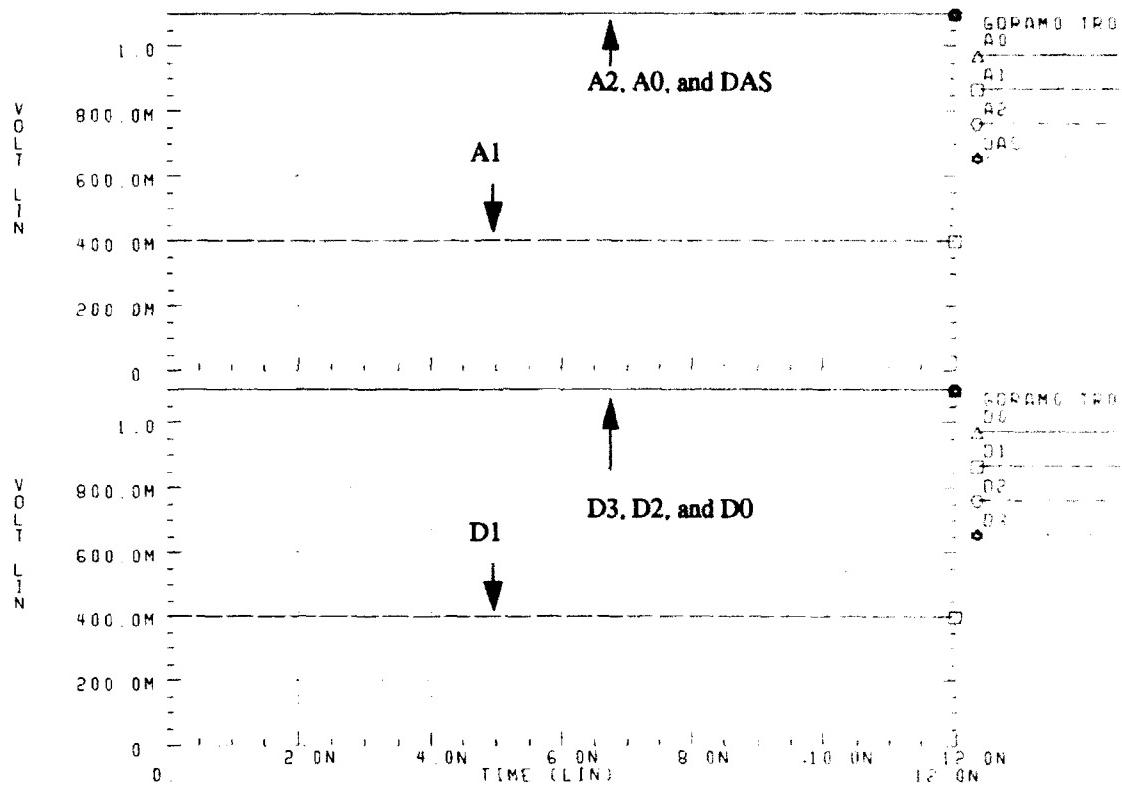


Figure 6.3 GaAs DRAM WRITE Operation at 25.0C (Part One)

The next figure, see Figure 6.4 on page 223, in the series presenting the WRITE operation shows the germane control signals, WRITE, MWRITE, READ, MREAD, PH1 and PH2. Notice that the x axis (time in nanoseconds) has been restricted to a zoom window of the period 2ns to 12ns. One may see the correct operation of the WRITEP circuitry, which establishes GaAs DRAM memory operation precedence, in this case, the WRITE has precedence over the READ. Notice also that as soon as the WRITE operation is completed (as signalled externally, albeit, somewhat artificially, by de-asserting the WRITE signal), the READ operation begins as indicated by the assertion of MREAD.

HSPICE PAD->PAD SIMULATION OF GAAS DRAM - WRITE OPERATION (PART TWO)

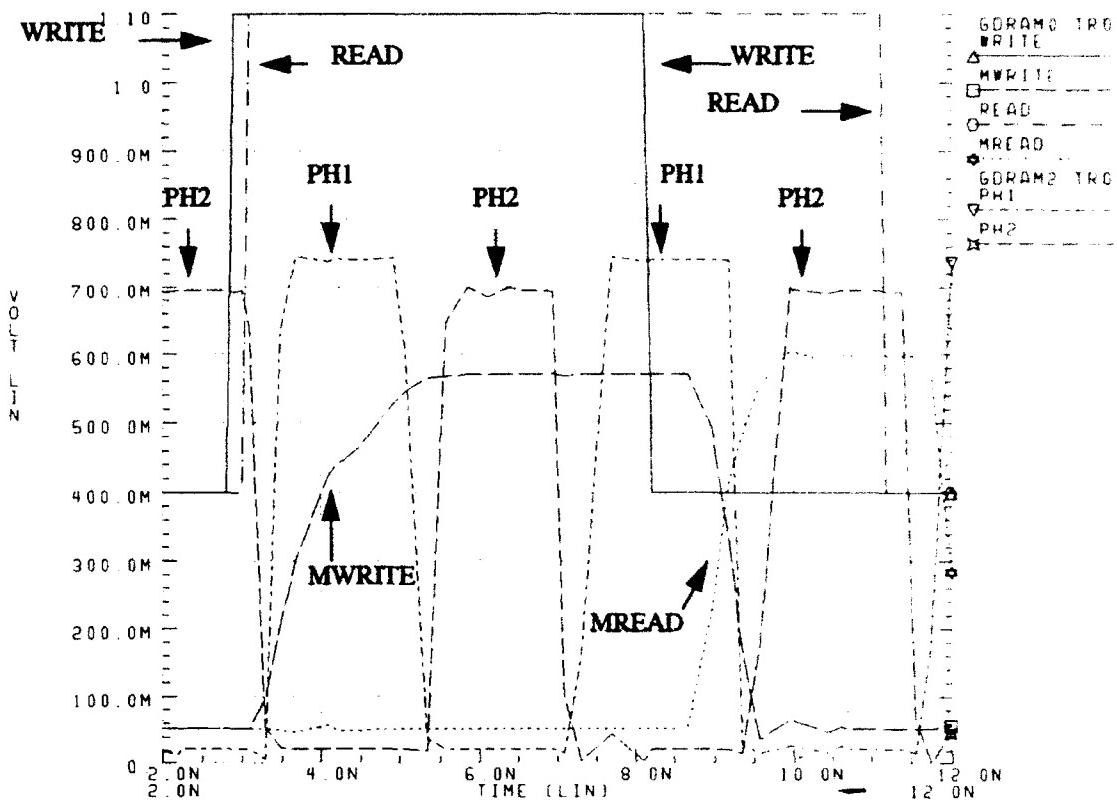


Figure 6.4 GaAs DRAM WRITE Operation at 25.0C (Part Two)

It should be noted at this point that, with regard to the timing of these memory operations, phase one (PH1) of the clock circuit exists almost entirely for the purposes of equalization and pre-charging operations within the RAM_ARRAY, see [Ref. 8:p. 12]. There is only one exception to this timing scheme and that is in the DREFRESH circuit. The exception will be fully discussed during the REFRESH operation of this chapter. Phase two of the GaAs DRAM clock timing scheme is the phase during which everything external to the RAM_ARRAY occurs (with the one exception noted). During the phase two (PH2) shown in Figure 6.4 the writing of the data occurs. In the next figure, see Figure 6.5 on page 224, the actual charge contents of the target memory addresses will be presented.

HSPICE PAD → PAD SIMULATION OF GAAS DRAM - WRITE OPERATION (PART THREE)

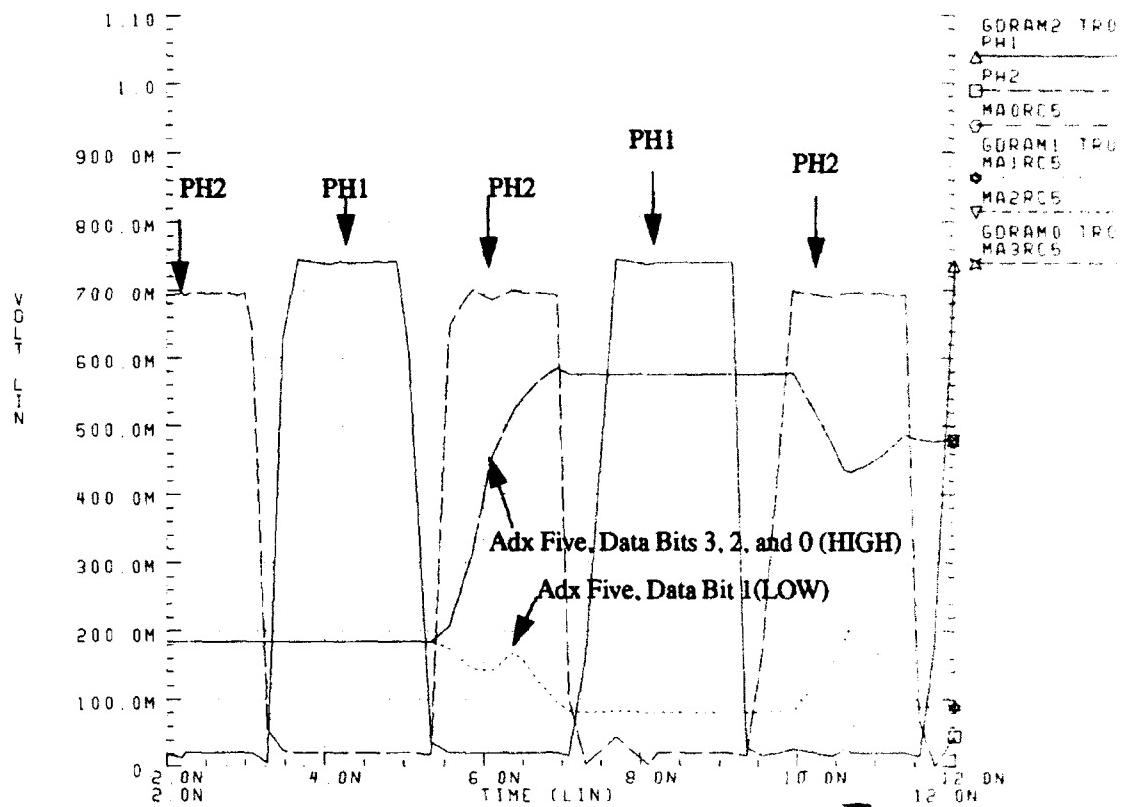


Figure 6.5 GaAs DRAM WRITE Operation at 25.0C (Part Three)

Looking at Figure 6.5, one sees, during the PH2 clock pulse at ~ 6.0 nanoseconds, the actual writing on the input data into the target address five. The activity shown during the PH2 clock pulse at ~11.0 nanoseconds, is a result of the READ operation which is the next topic to be discussed.

The next three figures demonstrate the same WRITE operation signals but at a simulation nominal temperature of 85.0C. See Figure 6.6 on page 225, Figure 6.7 on page 226, and Figure 6.8 on page 227.

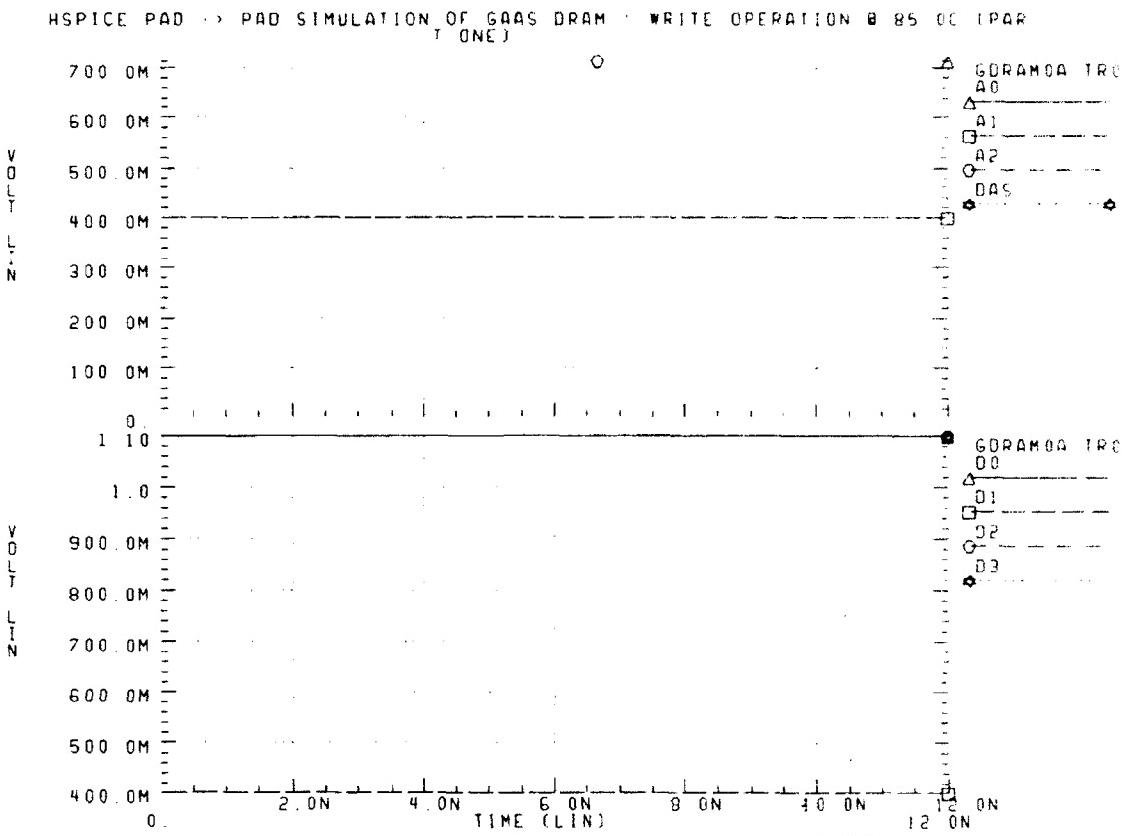


Figure 6.6 GaAs DRAM WRITE Operation at 85.0C (Part One)

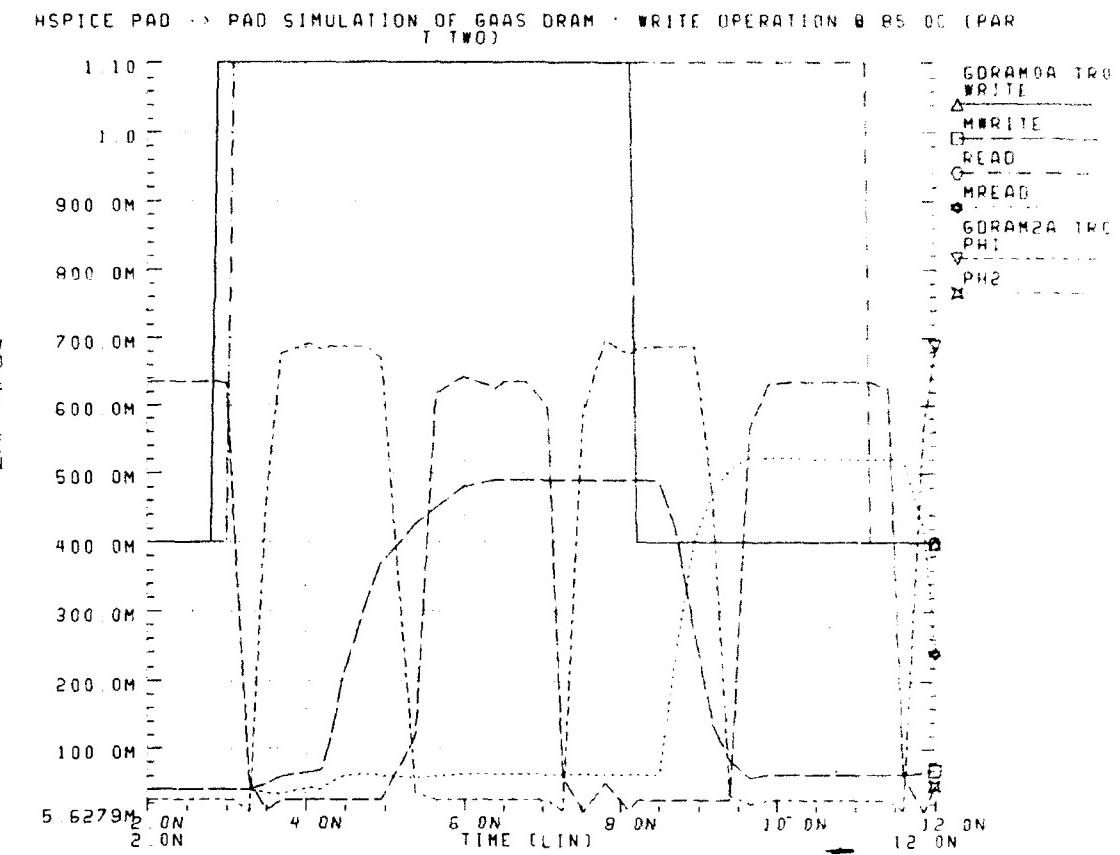


Figure 6.7 GaAs DRAM WRITE Operation at 85.0C (Part Two)

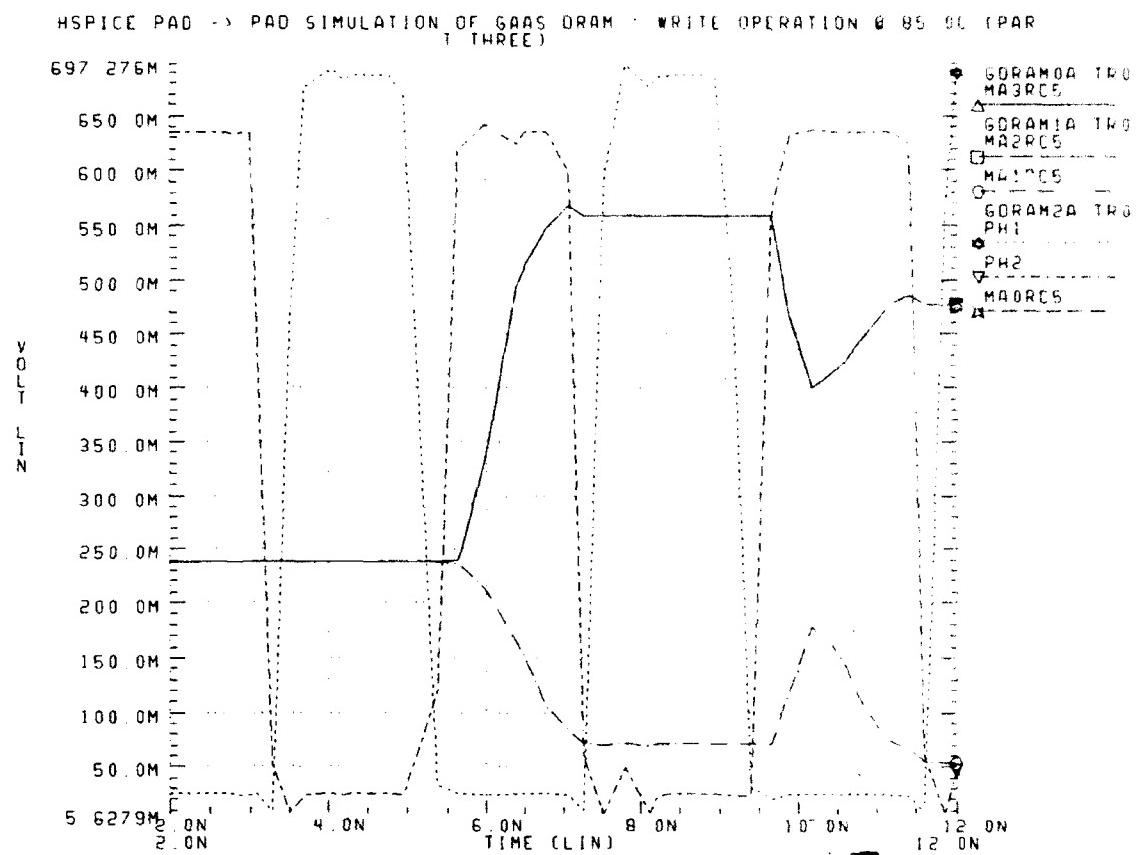


Figure 6.8 GaAs DRAM WRITE Operation at 85.0C (Part Three)

2. READ OPERATION

This section will discuss and demonstrate the execution of a GaAs DRAM READ operation. This READ operation occurs immediately after the previously mentioned WRITE operation so that the address and data parameters are the same. The first graph, see Figure 6.9 on page 228, shows the basic control signals of READ, MREAD, PH1, and PH2.

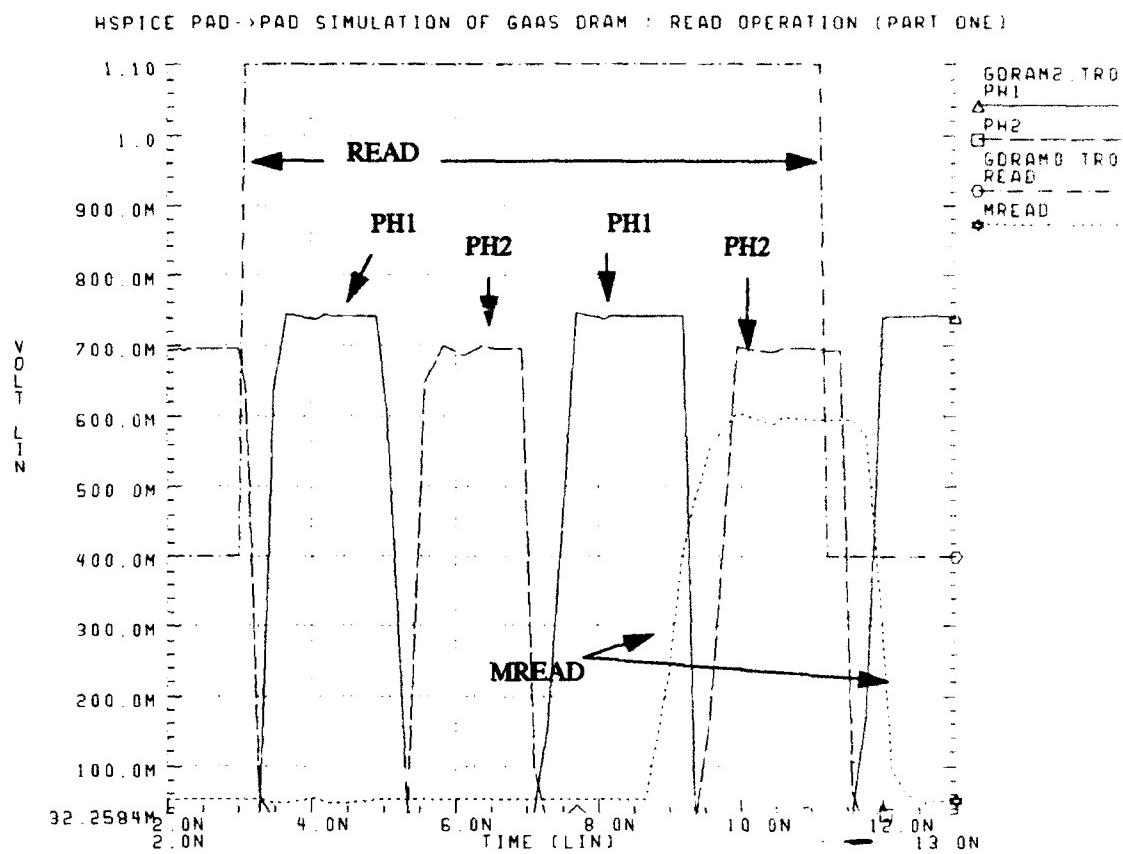


Figure 6.9 GaAs DRAM READ Operation at 25.0C (Part One)

Referring to Figure 6.9, the delay between the assertion of the external control signal READ and the assertion of the internal control signal MREAD occurs due to the preceding WRITE operation. In addition, notice that the x axis (time in nanoseconds) has again been restricted to a zoom window of the period 2 nanoseconds to 13 nanoseconds. The next figure, see Figure 6.10 on page 229, shows the basic internal control signals, MREAD and PH2, plus the actual charge contents of the target address, MA3RC5, MA2RC5, MA1RC5, and MA0RC5.

HSPICE PAD->PAD SIMULATION OF GAAS DRAM : READ OPERATION (PART TWO)

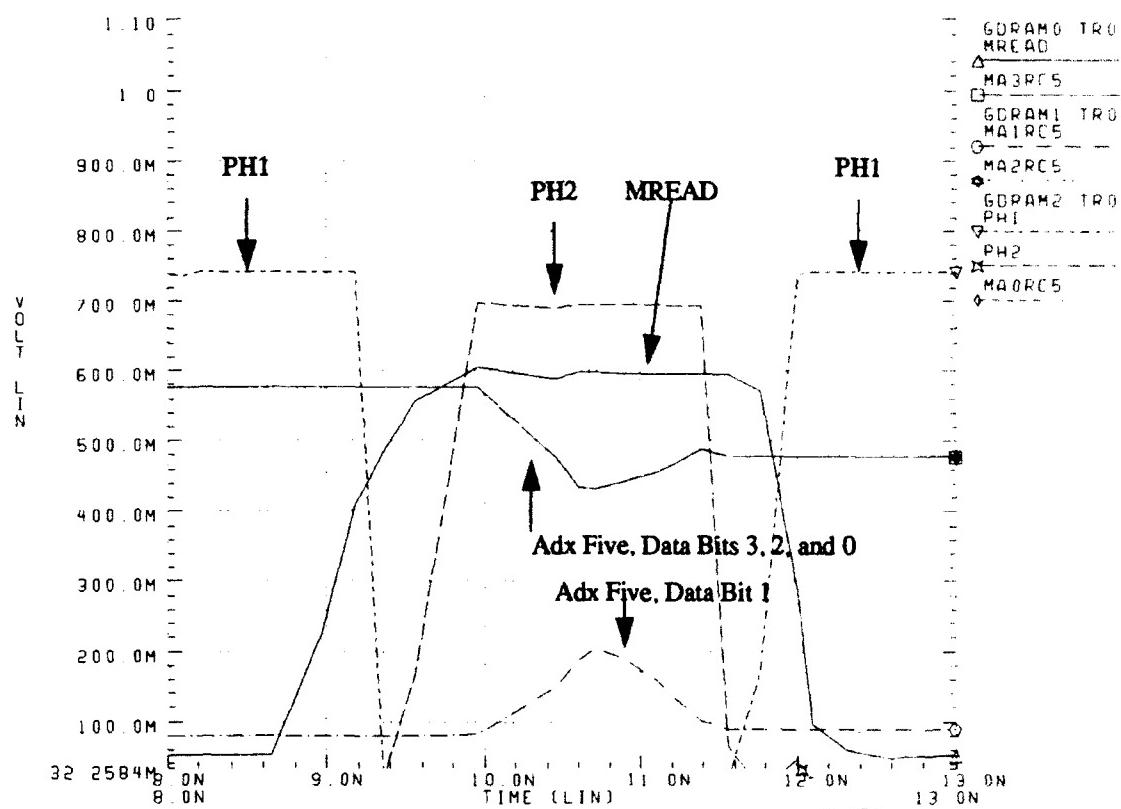


Figure 6.10 GaAs DRAM READ Operation at 25.0C (Part Two)

It may be seen in Figure 6.10, that the charge contents of the target address initially "dip" and recover to nearly their original charge levels during the READ operation. The reasons behind this phenomenon are thoroughly discussed in the works by Vagts [Ref 8:p. 14]. The next figure, see Figure 6.11 on page 230, demonstrates the operation of the two external control signals, memory busy (MBSY) and data ready (DRDY).

HSPICE PAD-to-PAD SIMULATION OF GAAS DRAM : READ OPERATION (PART THREE)

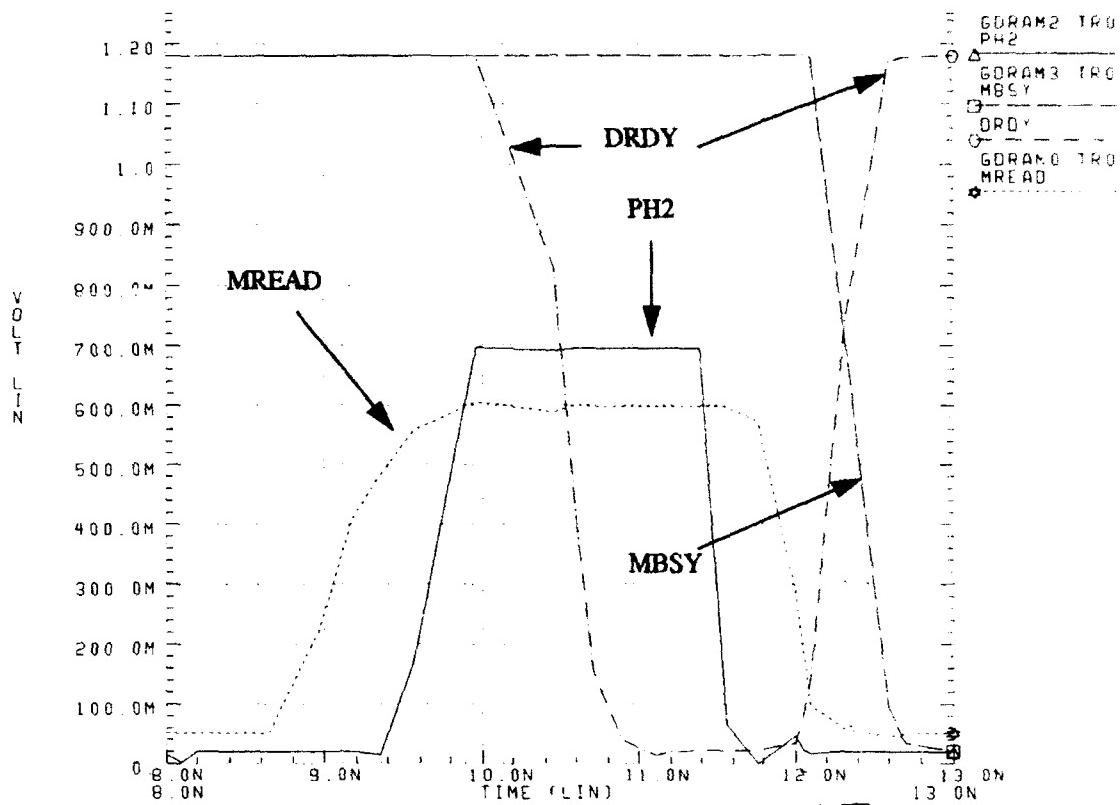


Figure 6.11 GaAs DRAM READ Operation at 25.0C (Part Three)

Examining Figure 6.11, it is seen that memory busy (MBSY) is initially HIGH indicating that the GaAs DRAM memory is busy performing a requested operation and that upon completion of the READ operation, the MBSY signal is de-asserted. Also, the data ready (DRDY) signal is initially asserted which indicates off-chip that the data from the most recently requested READ operation is still valid on the output data lines. Once the READ operation commences as synchronized to the leading edge of the EDUM or ODUM signals (not shown), DRDY is momentarily de-asserted until the completion of the latching of the output data. The next figure, see Figure 6.12 on page 231, shows the output data lines and the output control signals, MBSY and DRDY.

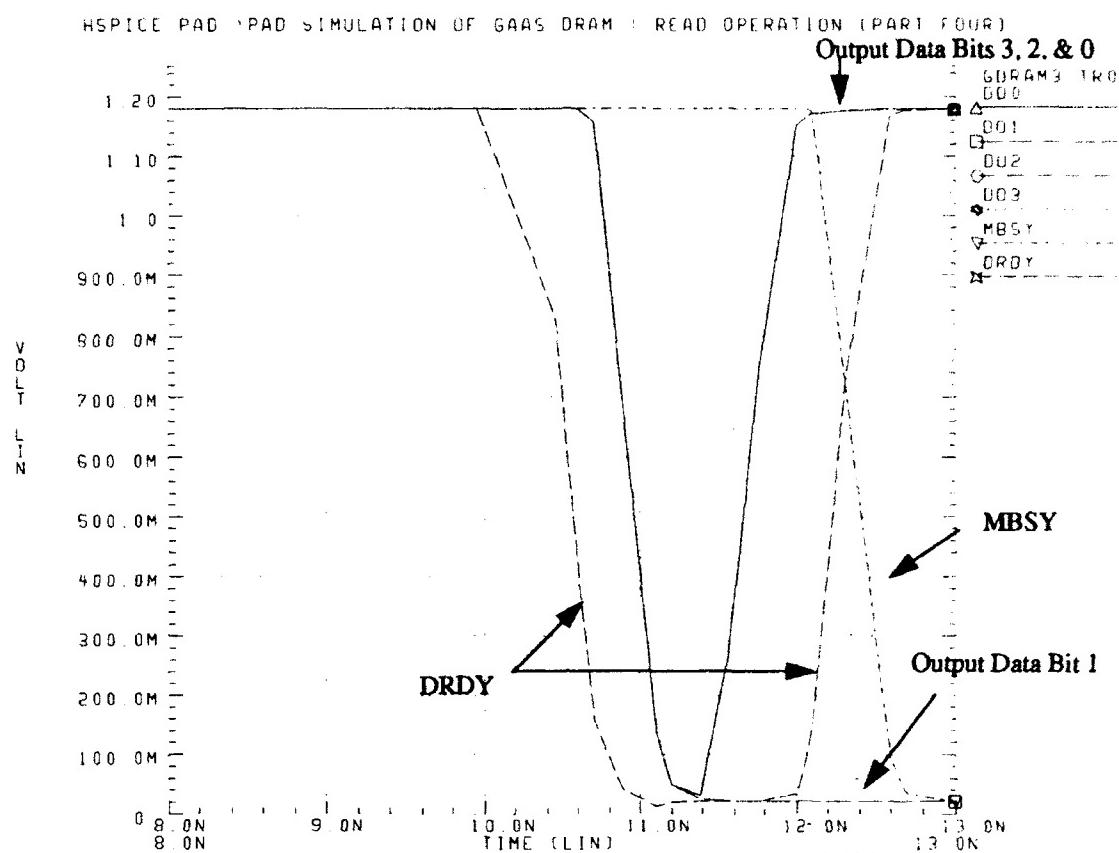


Figure 6.12 GaAs DRAM READ Operation at 25.0C (Part Four)

Referring to Figure 6.12, it may be seen that the output data lines indicate the last READ operation returned data values equal to D3 = 1, D2 = 1, D1 = 0, and D0 = 1. This is a correct result based on the input data previously written to the GaAs DRAM memory. Notice also that the DRDY signal is not asserted until the output data is latched and steady.

With regard to the overall operational precedence and in view of the fact that the input control signals WRITE and READ are not latched, it must be noted that if, in the midst of a READ or WRITE operation, a REFRESH is asserted then depending on the timing (and luck!), the READ or WRITE operation in progress may be "trounced" and become invalid. This control design shortcoming should be addressed in revisions to the design.

The next four figures demonstrate the same READ operation signals but at a simulation nominal temperature of 85.0C. See Figure 6.13 on page 232, Figure 6.14 on page 233, Figure 6.15 on page 234, and Figure 6.16 on page 235.

HSPICE PAD → PAD SIMULATION OF GAAS DRAM READ OPERATION @ 85.0C (PART ONE)

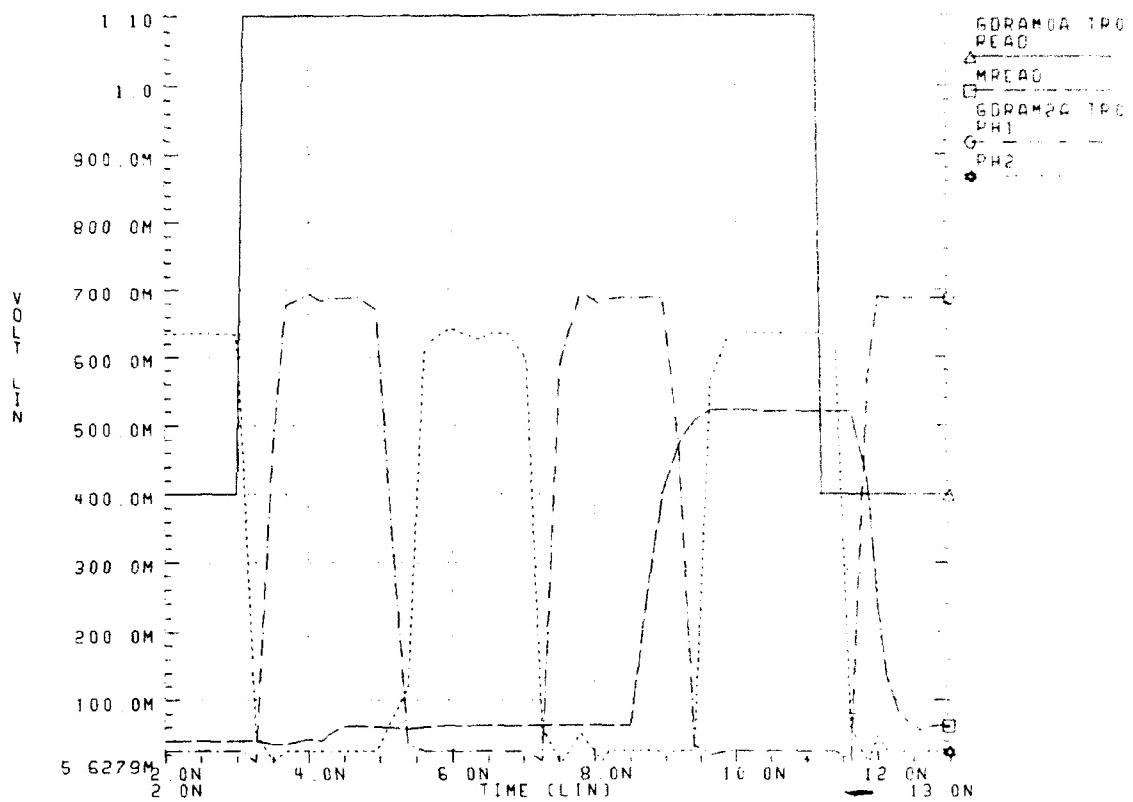


Figure 6.13 GaAs DRAM READ Operation at 85.0C (Part One)

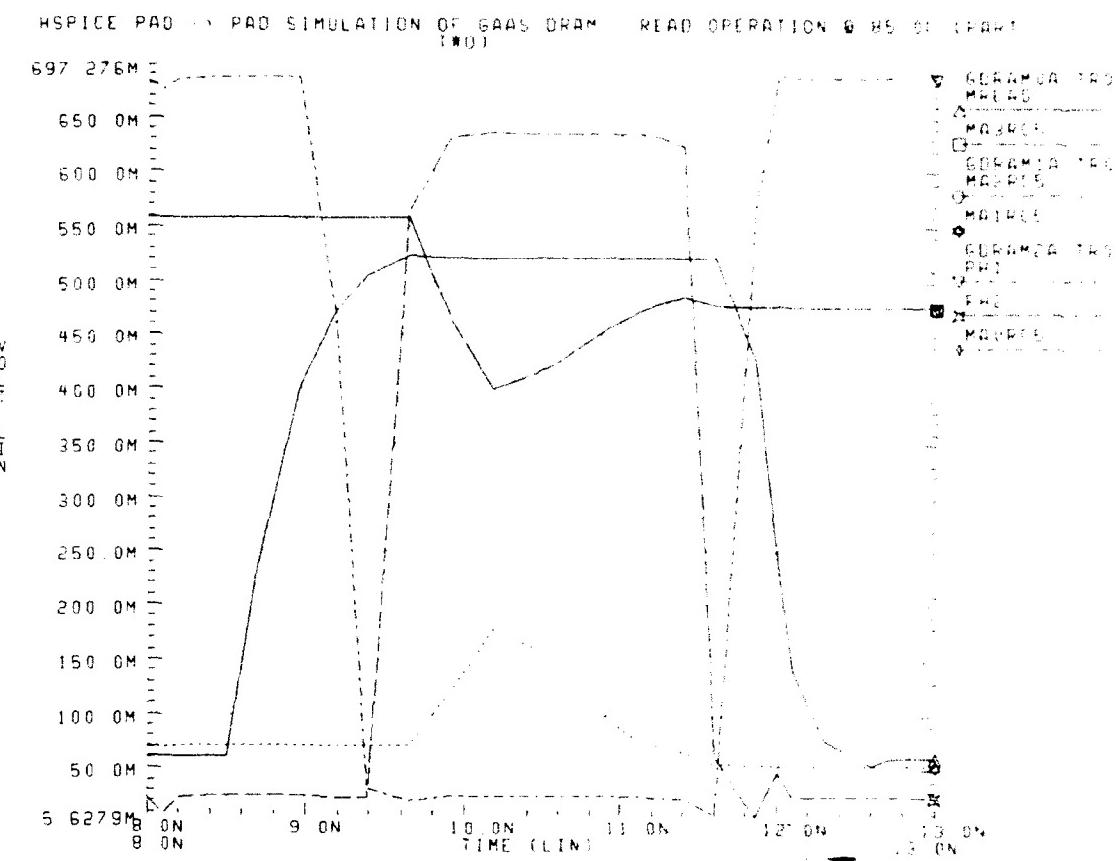


Figure 6.14 GaAs DRAM READ Operation at 85.0C (Part Two)

HSPICE PAD → PAD SIMULATION OF GAAS DRAM · READ OPERATION @ 85.0C (PART THREE)

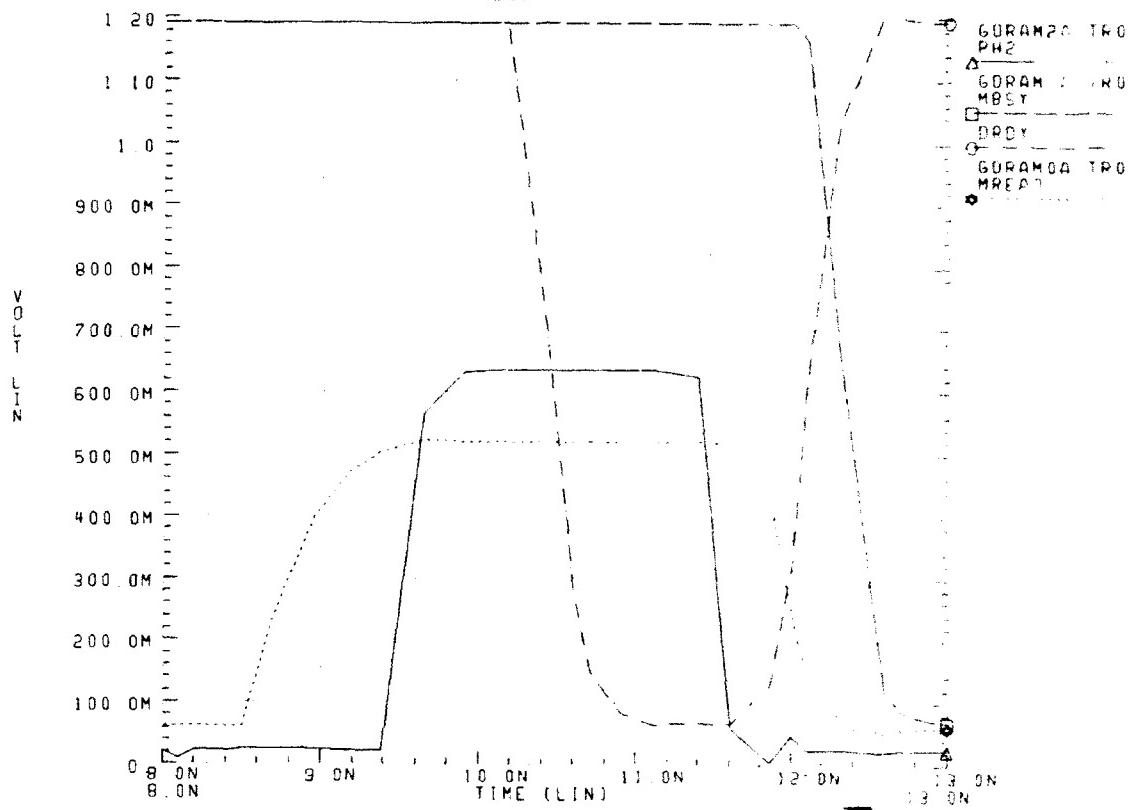


Figure 6.15 GaAs DRAM READ Operation at 85.0C (Part Three)

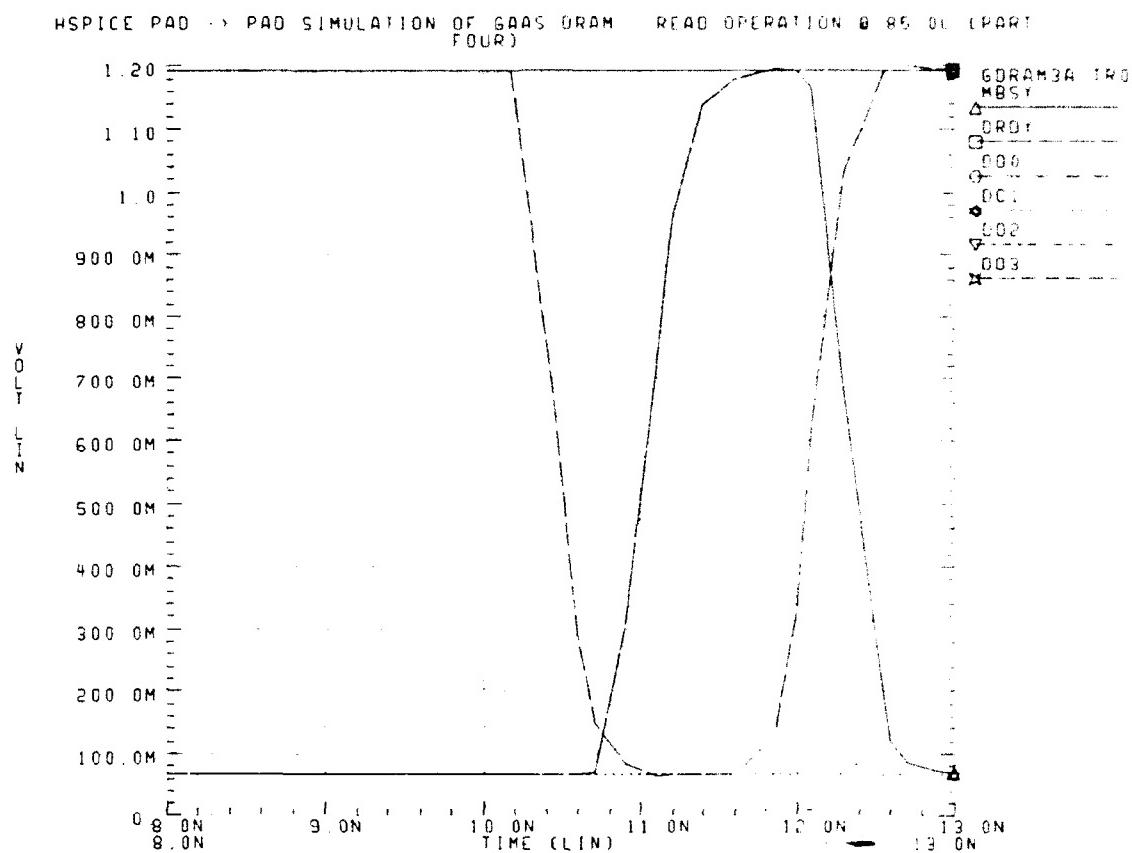


Figure 6.16 GaAs DRAM READ Operation at 85.0C (Part Four)

3. REFRESH OPERATION

This section will discuss and demonstrate the refresh operation which follows the WRITE and then READ in the same HSPICE GaAs DRAM pad to pad simulation execution. The REFRESH logic circuitry was the most difficult to design, as previously discussed in Chapter V. See "DRAM Refresh Circuitry (DREFRESH)" on page 176. The first figure in this discussion of the REFRESH operation, see Figure 6.17 on page 236, presents the control signals associated with REFRESH in the upper graph and the outputs of the DREFRESH circuitry in the lower graph. Notice also that in Figure 6.17, the upper and lower panels are time "zoomed", synchronized graphs such that the PH1 signals in the upper graph also reflect accurately the assertion times of the signals in the lower graph.

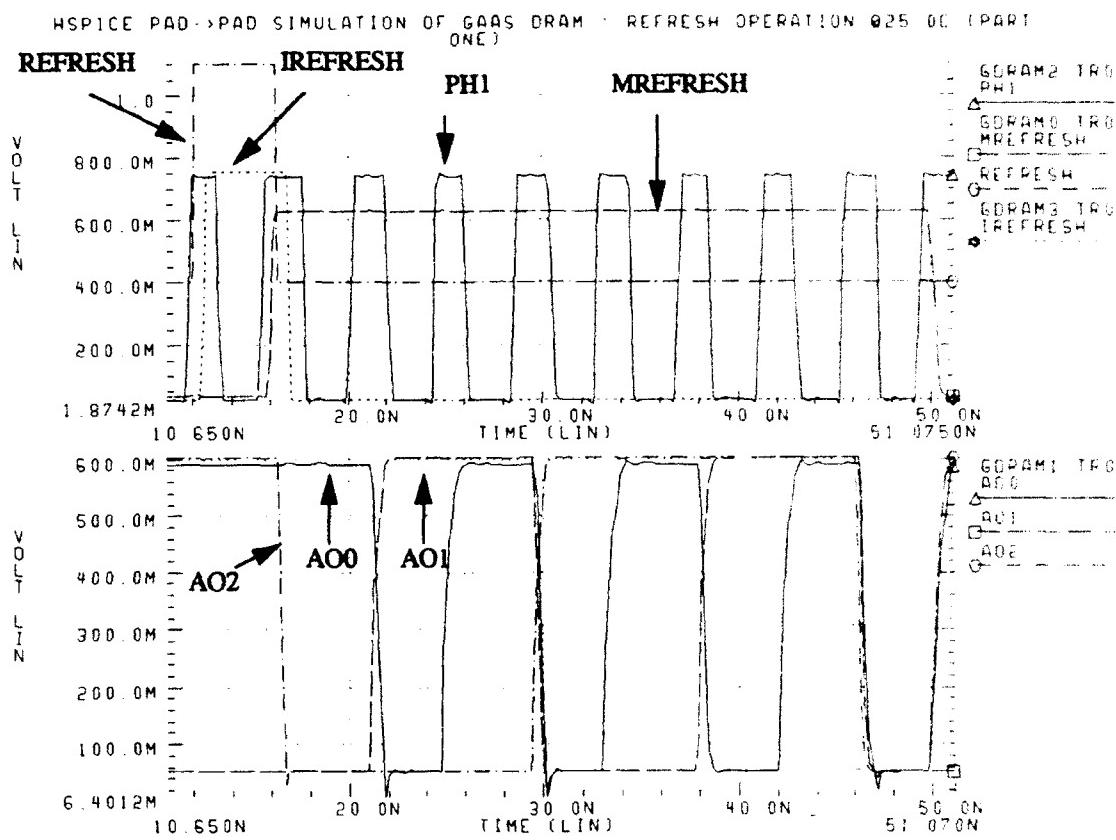


Figure 6.17 GaAs DRAM REFRESH Operation at 25.0C (Part One)

Referring to Figure 6.17 (upper graph), the external control signal REFRESH is asserted at approximately 10.65 nanoseconds and the refresh signal is passed through the pad receiver to become the IREFRESH (Intermediate) signal. The pad receiver propagation delay causes the IREFRESH to just miss the leading edge of the PH1 clock pulse and so MREFRESH does not occur until the next leading edge of the PH1 clock pulse. Those wishing to review the DREFRESH circuitry may see Figure 5.14 on page 177. This is the exception mentioned previously to the fact that almost all the activity that occurs with the GaAs DRAM design but external to the RAM_ARRAY, occurs during the PH2 clock pulse. Once the MREFRESH signal is asserted, the GaAs DRAM commences a refresh operation. The lower graph of Figure 6.17 demonstrates the output signals, AO2 - AO0, of the DREFRESH circuitry. These signals represent the counting sequence output by the DREFRESH circuitry to sequentially access all addresses in the GaAs DRAM memory array. It should be mentioned that the counting sequence does not begin with address zero as one might assume. Per

the previous discussion of HSPICE simulation initial conditions, viewing Figure 6.17, one may see that this is exactly what occurs.

In the DECODDRV circuitry, the AO2 - AO0 signals coupled with the now asserted MREFRESH signal, causes the sequential assertion of the DRAM address driver signals, DA7 - DA0. Notice that the driver address signals are level shifted as these signals control the depletion mode GaAs MESFET DRAM access transistors. These signals are shown in Figure 6.18 on page 237.

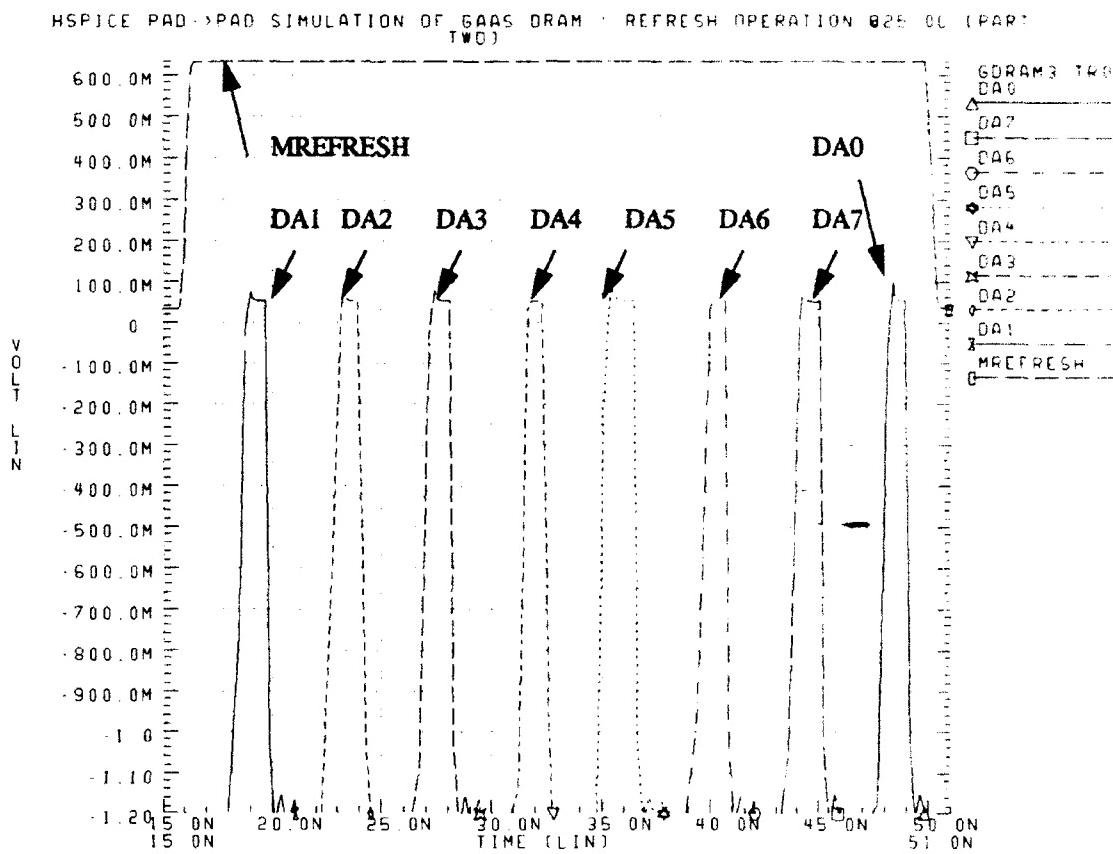


Figure 6.18 GaAs DRAM REFRESH Operation at 25.0C (Part Two)

Examining Figure 6.18, one sees the sequential assertion of the driver address signals, DA1 to DA7 to DA0. Notice again that this graph is x axis specified to display only the time frame of 15.0 nanoseconds to 51.0 nanoseconds. The final graph for the demonstration of the REFRESH operation includes the address five charge contents, the address three charge contents (for non-target comparison purposes), the output control signal MBSY, and several other germane signals, see Figure 6.19 on page 238.

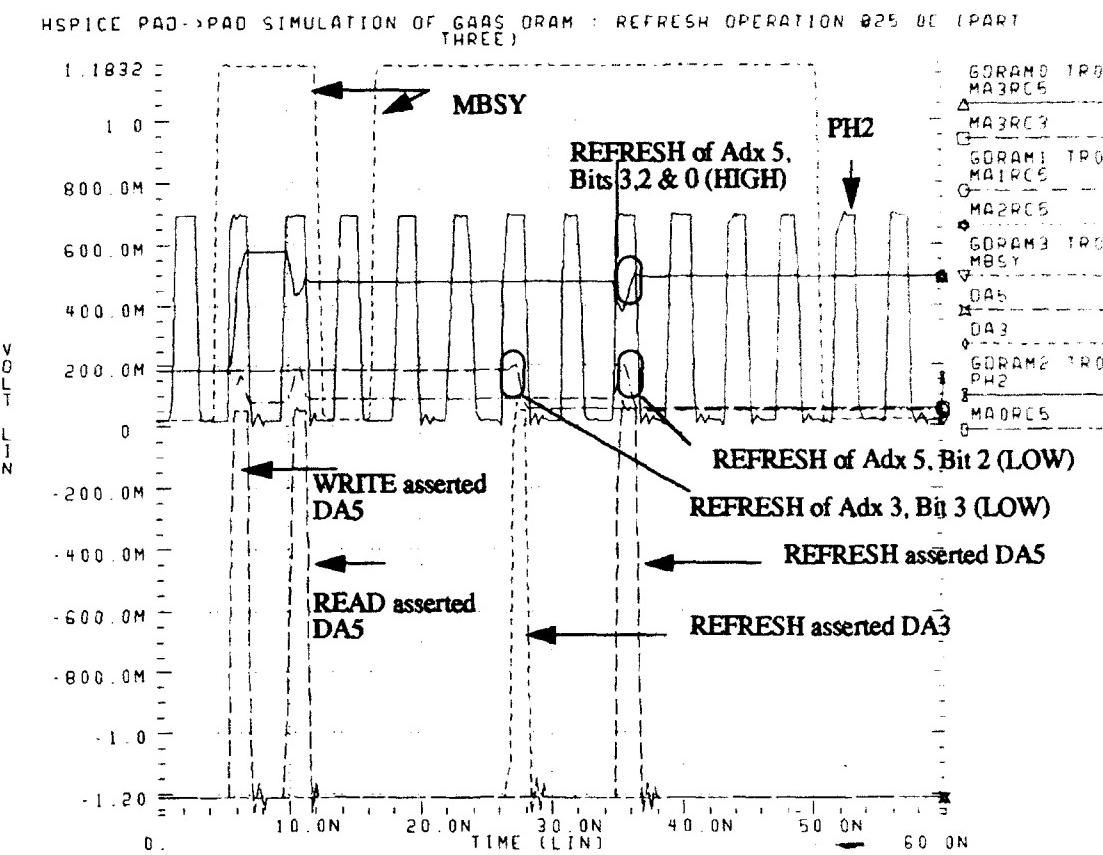


Figure 6.19 GaAs DRAM REFRESH Operation at 25.0C (Part Three)

Viewing Figure 6.19, one can immediately see quite a lot of information. First, the x axis (time in nanoseconds) is not zoom specified so that the entire HSPICE GaAs DRAM simulation interval may be seen. Secondly, the previously discussed WRITE and READ operation effects on address five (the target address) may be seen. Thirdly, the additional, non-target, memory address three charge contents are displayed for comparison purposes. Furthermore, the specific REFRESH effects are shown for address five, all four data bits. The effects of the REFRESH operation on the target address five are as expected. The data bits 3, 2, and 0 are refreshed to HIGH and the data bit 1 is refreshed to a LOW. Finally, the MBSY signal is demonstrated for the entire simulation interval to give a better idea of its operation.

The next three figures display the same REFRESH operation signals but at a simulation nominal temperature of 85.0C. See Figure 6.20 on page 239, Figure 6.21 on page 240, and Figure 6.22 on page 241.

HSPICE PAD → PAD SIMULATION OF GaAs DRAM : REFRESH OPERATION @ 85.0C (P
ART ONE)

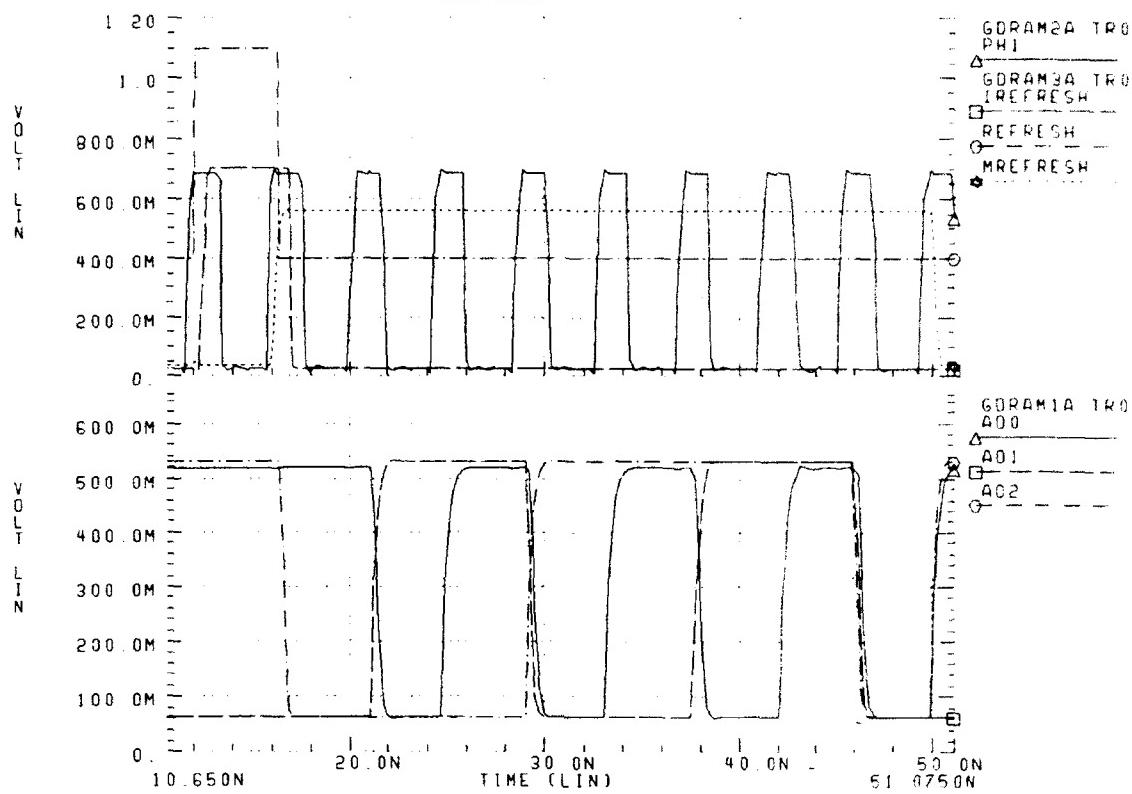


Figure 6.20 GaAs DRAM REFRESH Operation at 85.0C (Part One)

HSPICE PAD → PAD SIMULATION OF GAAS DRAM - REFRESH OPERATION @ 85.0C (P
ART TWO)

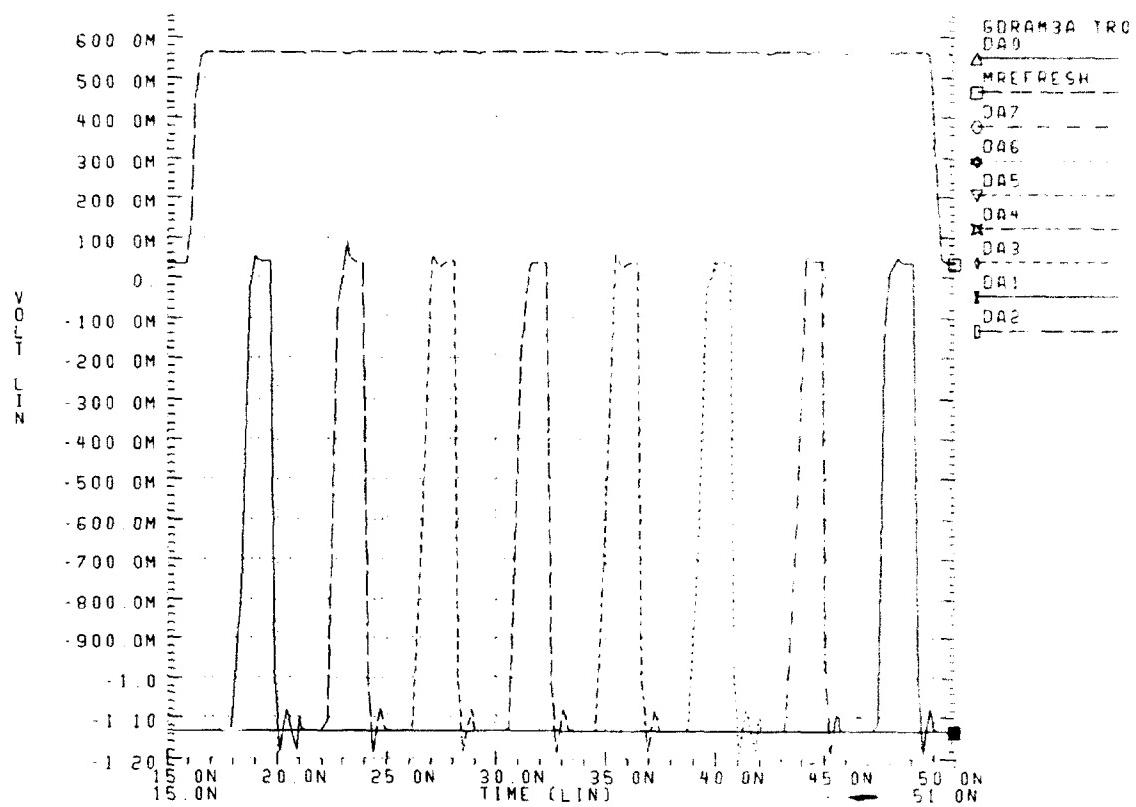


Figure 6.21 GaAs DRAM REFRESH Operation at 85.0C (Part Two)

HSPICE P40 -> PAD SIMULATION OF GAAS DRAM : REFRESH OPERATION @ 85.0C (P
ART THREE E)

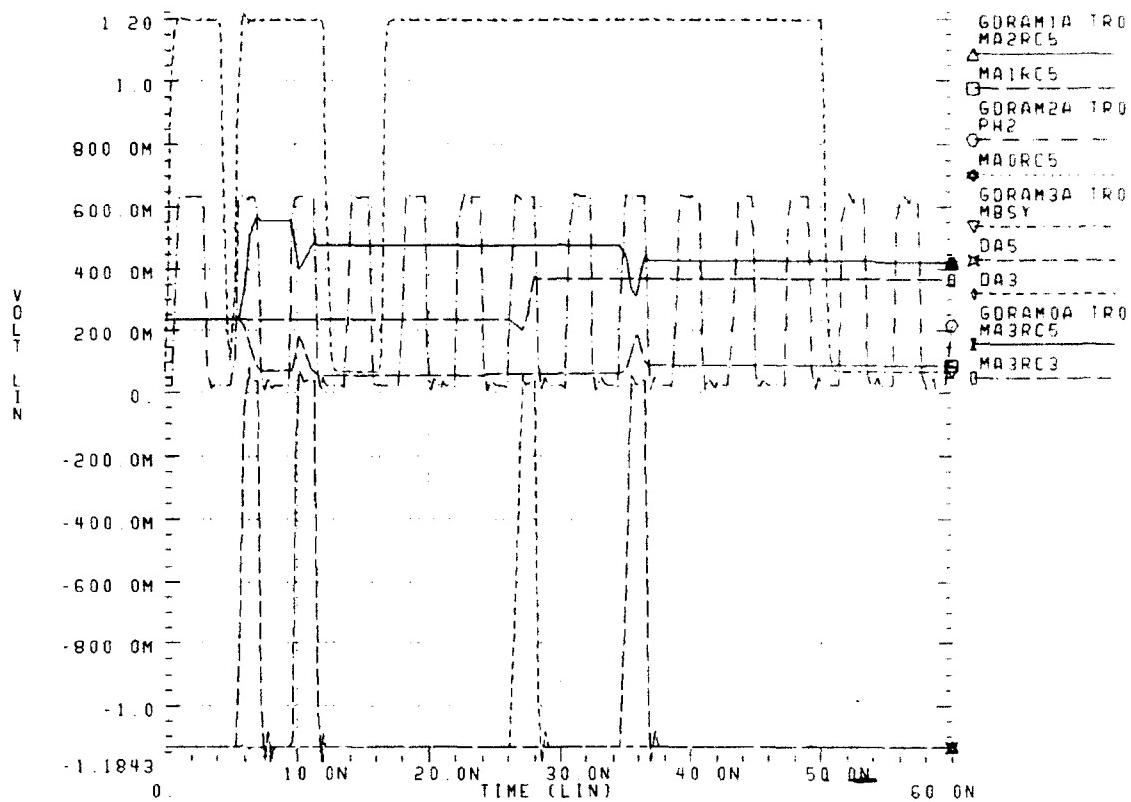


Figure 6.22 GaAs DRAM REFRESH Operation at 85.0C (Part Three)

D. GaAs DRAM POWER CONSUMPTION

The power consumption of the GaAs DRAM memory array circuit was certainly a concern. However, there were no power consumption optimization techniques employed. The absolute main thrust of the research was the design, validation, and fabrication of a functioning GaAs DRAM memory array constructed entirely using the industry standard GaAs fabrication process and materials. The next two figures provide power consumption for GaAs DRAM memory array, see Figure 6.23 on page 242 and Figure 6.24 on page 243.

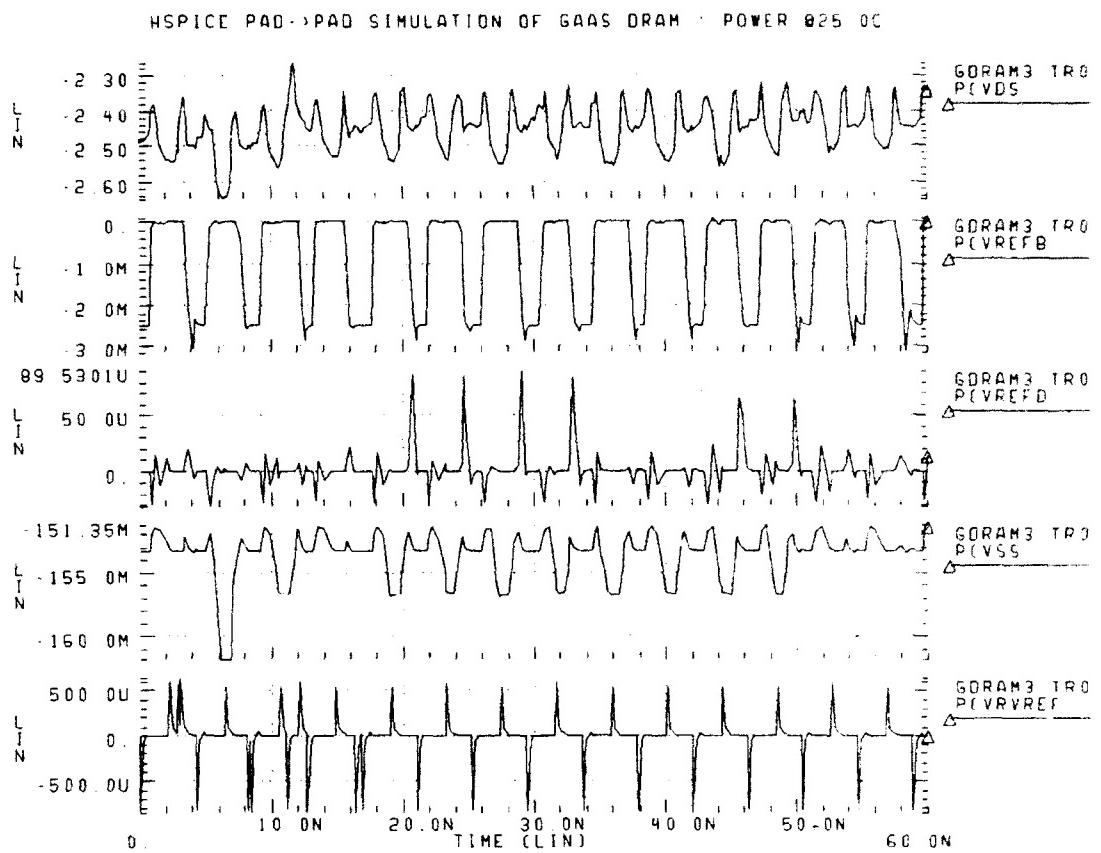


Figure 6.23 GaAs DRAM Memory Array Power Consumption @25.0C

Examining Figure 6.23, the power consumption graphs for all five of the external power supplies are provided. The uppermost graph displays the power consumption of the main power supply, V_{DS} . The HSPICE AVG function calculates the average power consumption of V_{DS} over the entire length of the simulation run (60 nanoseconds) to be 2.45 watts. The next graph of Figure 6.23 (second from top) displays the power consumption for the V_{REFB} . The HSPICE AVG function calculates the average power consumption of V_{REFB} over the entire length of the simulation run (60 nanoseconds) to be 9.15E-4 watts. The middle graph of Figure 6.23 presents the power consumption of V_{REFD} . The HSPICE AVG function calculates the average power consumption of V_{REFD} over the entire length of the simulation run (60 nanoseconds) to be 1.35E-6 watts. The fourth graph of Figure 6.23 demonstrates the power consumption of the V_{SS} power supply. The HSPICE AVG function calculates the average power consumption of V_{SS} over the entire length of the simulation run (60 nanoseconds) to be 1.54E-1 watts. The last graph of Figure 6.23 (fifth from top) displays the power

consumption of the V_{AVREF} power supply, which provides a reference voltage level to the 12 pad receiver circuits, as previously mentioned. The power consumption average values used here may be found in the HSPICE listing files. See "Run #1 LISTING FILE" on page 379.

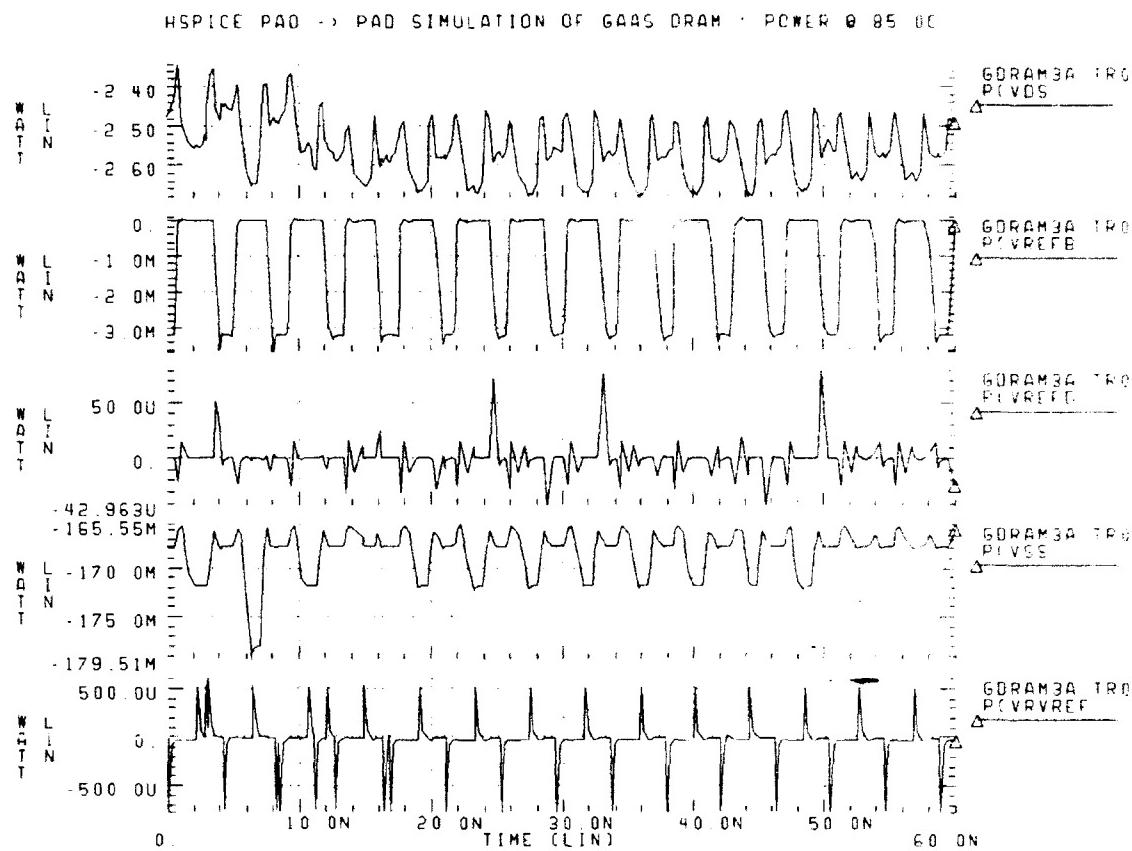


Figure 6.24 GaAs DRAM Memory Array Power Consumption @85.0C

E. SUMMARY OF GaAs DRAM MEMORY CHARACTERISTICS

The purpose of this summary is to collect some of the important characteristics of the GaAs DRAM memory design. Probably, the single most referenced DRAM characteristic is memory access time. Wakerly [REF 9:p. 642] defines the most commonly used access time to be t_{AA} , *access time from address* to be how long it takes (assuming the memory chip is already enabled) to achieve stable output data after the memory address is changed. For the GaAs DRAM, because the simulation used pre-set voltage levels for the input address lines, this report will define the memory access time to be from the time the external READ signal is asserted to the time that the output data is stable as reported by the assertion of the DRDY signal.

1. GaAs DRAM Minimum READ Operation

The following three figures will present a minimum access time READ operation at a simulation nominal temperature of 25.0 C. Address six was used as the target address for the minimum READ operation simulation. Additionally, the data contents of target address six were set to D3 = 0, D2 = 1, D1 = 0, and D0 = 1, using the HSPICE ".IC" option. The actual voltage values used were derived from the results of the previously discussed HSPICE pad-to-pad WRITE operation, a "1" = 0.437 volts and a "0" = 0.0728 volts. Examining Figure 6.25 on page 244, one may see the assertion of the external READ signal, the assertion of the MREAD signal, and the two fundamental clock pulses, PH1 and PH2.

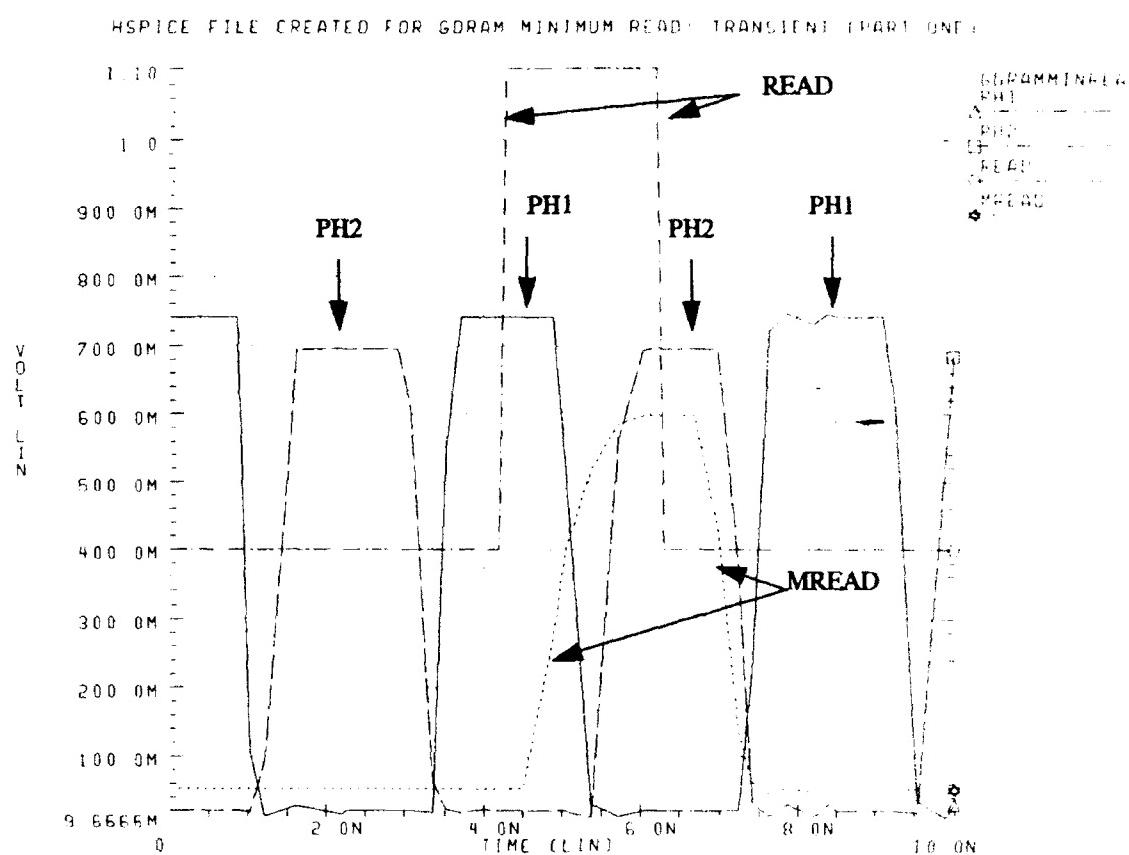


Figure 6.25 GaAs DRAM Minimum READ Operation: Transient Analysis (Part One)

Referring to Figure 6.25, as previously mentioned, it is not necessary to include the PH1 clock pulse in the minimum READ operation. This is because the PH1 clock pulse is only used internally in the RAM_ARRAY during a READ. The next figure of the minimum READ operation, Figure 6.26 on page 245,

presents the target address (address six) data outputs (DO3 - DO0), the charge contents of the target address (MA3RC6 - MA0RC6), and the two main clock pulses, PH1 and PH2.

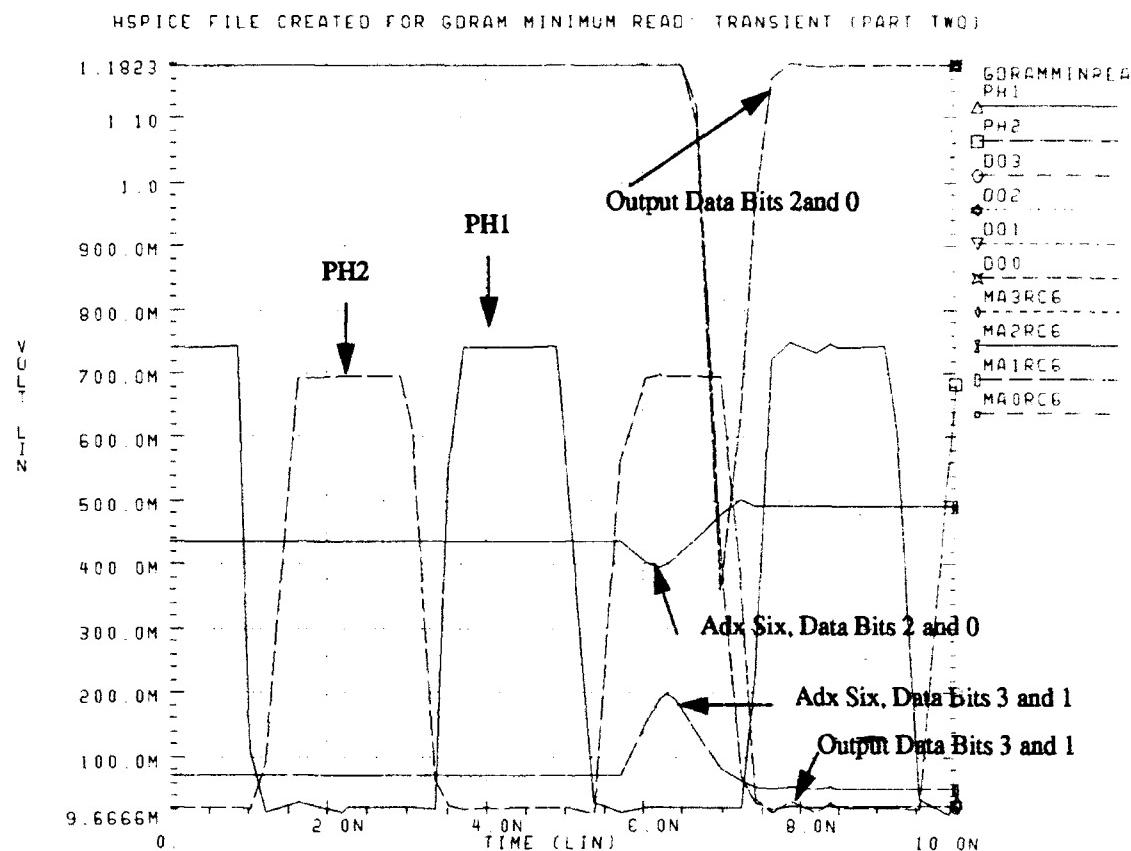


Figure 6.26 GaAs DRAM Minimum READ Operation: Transient Analysis (Part Two)

The final figure of the GaAs DRAM minimum READ operation, Figure 6.27 on page 246, demonstrates the assertion of the READ signal, the assertion of the MREAD signal, and the associated activity of the memory status control signals, MBSY and DRDY.

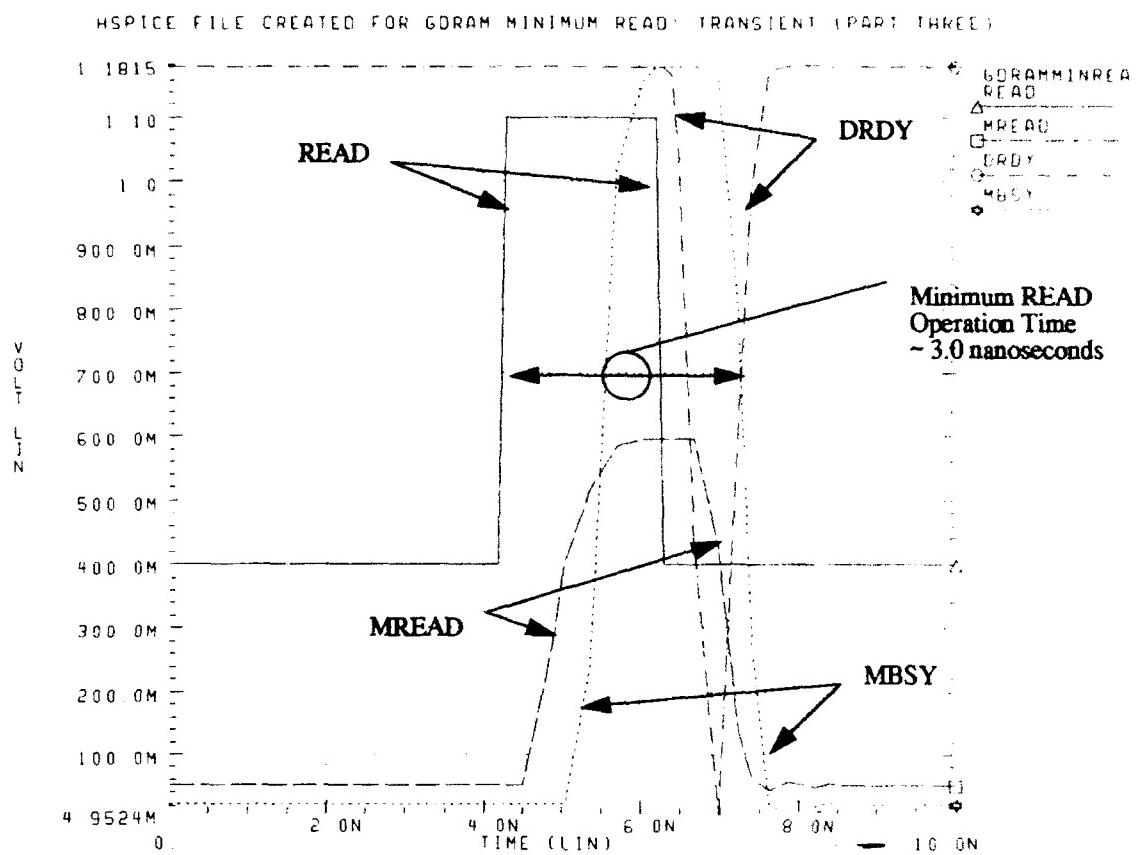


Figure 6.27 GaAs DRAM Minimum READ Operation: Transient Analysis (Part Three)

In Figure 6.27, one may see the defining interval for a GaAs DRAM minimum READ operation. This interval, as previously defined, is approximately 3.0 nanoseconds. The HSPICE AVG function calculated an average power, ($p(V_{DS})$), of 0.392 milliwatts over the minimum READ operation target interval.

2. GaAs DRAM Minimum WRITE Operation

The following three figures will present a minimum access time WRITE operation at a simulation nominal temperature of 25.0 C. Address seven was used as the target address for the minimum WRITE operation simulation. Additionally, the input data bits were set to D3 = 0, D2 = 1, D1 = 0, and D0 = 1. Examining Figure 6.28 on page 247, one may see the assertion of the external WRITE signal, the assertion of the MWRITE signal, and the two fundamental clock pulses, PH1 and PH2.

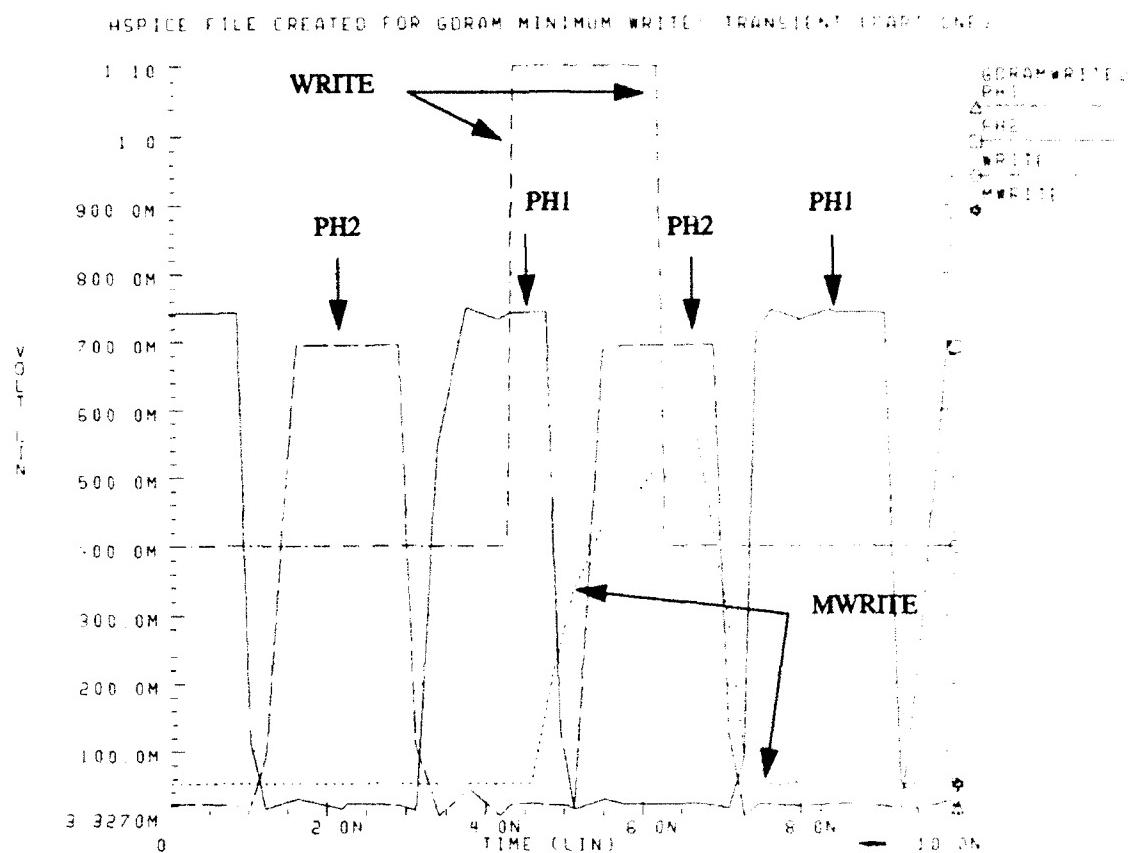


Figure 6.28 GaAs DRAM Minimum WRITE Operation: Transient Analysis (Part One)

For the reasons previously mentioned, the PH1 clock pulse is also not required for a GaAs DRAM minimum WRITE operation. Thus notice in Figure 6.28, the external WRITE is asserted such that the MWRITE signal becomes HIGH immediately prior to the rising edge of PH2. The next figure, Figure 6.29 on page 248, shows the writing of target address seven (MA3RC7 - MA0RC7) and the two fundamental clock pulses, PH1 and PH2.

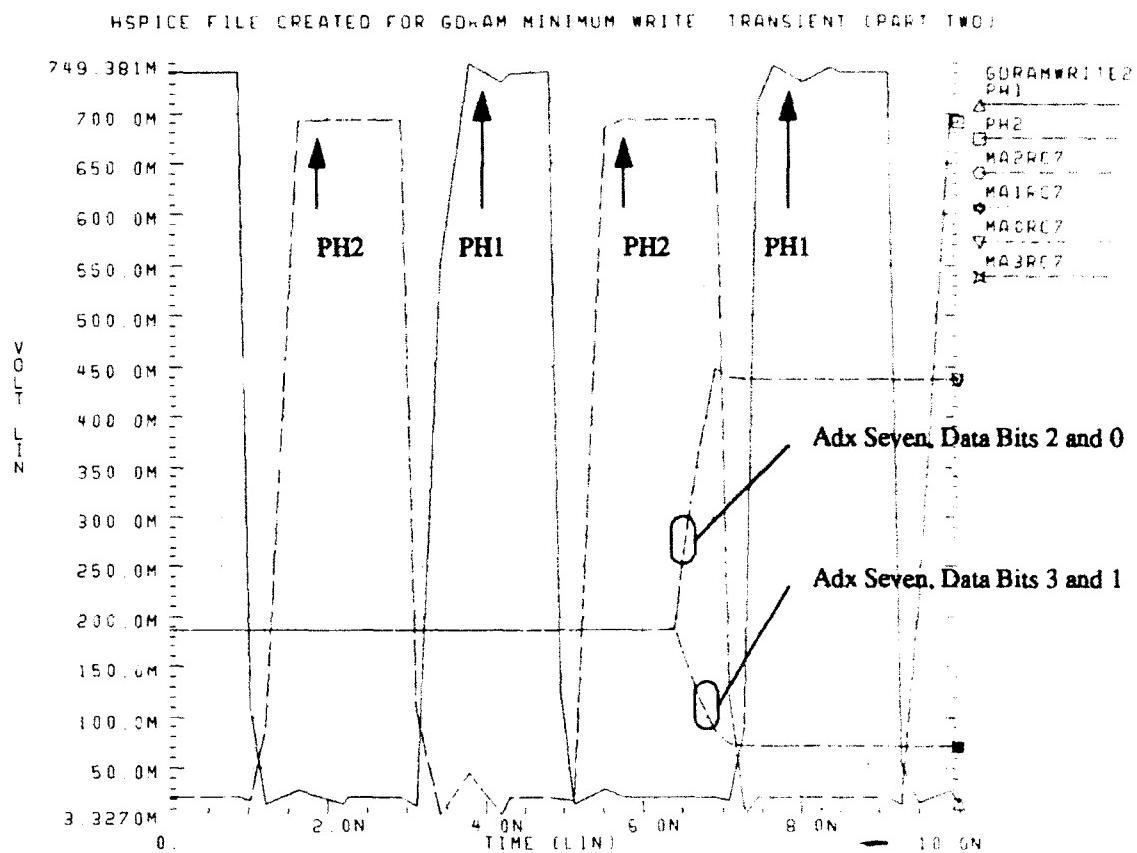


Figure 6.29 GaAs DRAM Minimum WRITE Operation: Transient Analysis (Part Two)

The final figure of the GaAs DRAM minimum WRITE operation, Figure 6.30 on page 249, demonstrates the assertion of the WRITE signal, the assertion of the MWRITE signal, and the associated activity of the memory status control signal, MBSY.

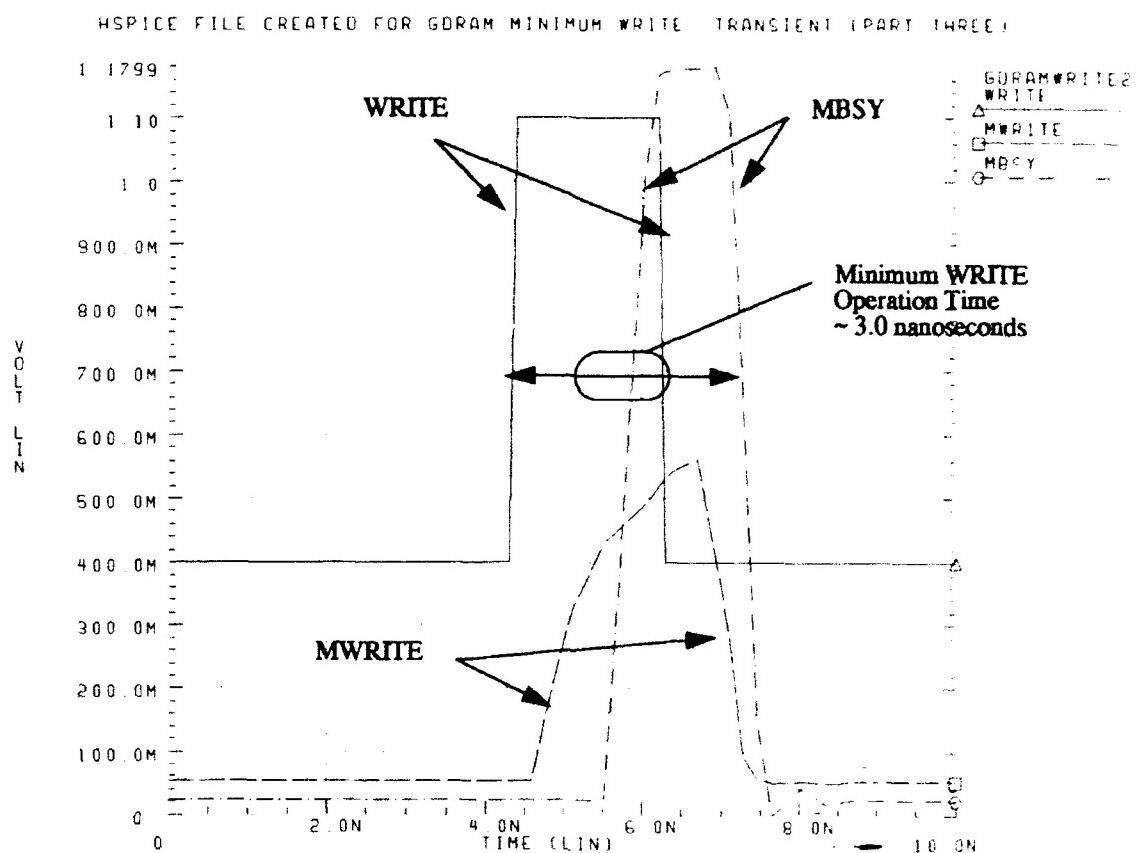


Figure 6.30 GaAs DRAM Minimum WRITE Operation: Transient Analysis (Part Three)

In Figure 6.30, one may see the defining interval for a GaAs DRAM minimum WRITE operation. This interval, defined to begin when the external control signal WRITE is asserted and to end when the external memory status control signal MBSY is de-asserted, is approximately 3.0 nanoseconds. The HSPICE AVG function calculated an average power, ($p(V_{DS})$), of 2.45 watts over the minimum WRITE operation target interval. For a through discussion of the RAM_ARRAY WRITE operation specifics, see the work of Vagts [Ref. 8:pp. 17-23].

3. GaAs DRAM Minimum REFRESH Operation

The following three figures will present a minimum time REFRESH operation at a simulation nominal temperature of 25.0 C. The data contents of address six were set to D3 = 0, D2 = 1, D1 = 0, and D0 = 1, using the HSPICE ".IC" option. The actual voltage values used were derived from the results of the previously discussed HSPICE pad-to-pad WRITE operation, a "1" = 0.437 volts and a "0" = 0.0728 volts.

Examining Figure 6.31 on page 250, one may see the assertion of the external REFRESH signal, the assertion of the MREFRESH signal, and the two fundamental clock pulses, PH1 and PH2.

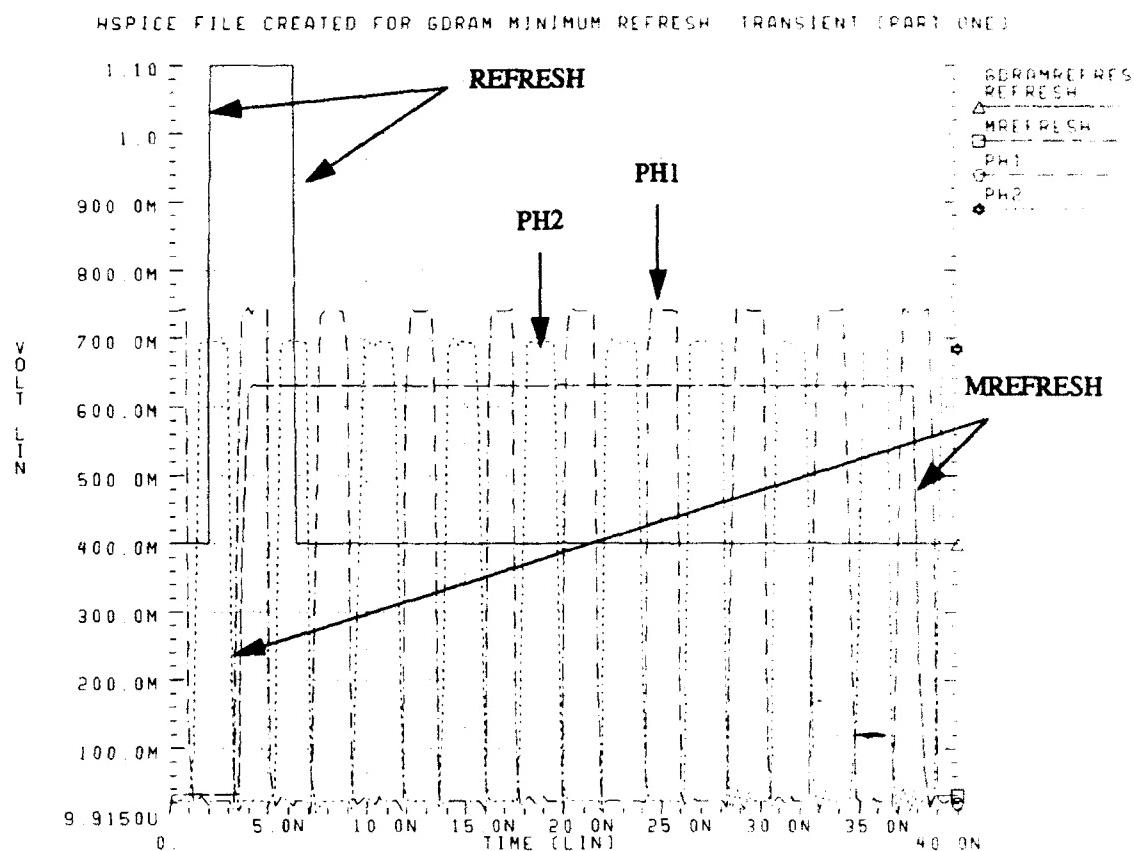


Figure 6.31 GaAs DRAM Minimum REFRESH Operation: Transient Analysis (Part One)

The next figure, Figure 6.32 on page 251, shows the REFRESH effects on the target address (six), the DRAM address driver signal DA6, and the two fundamental clock pulses, PH1 and PH2.

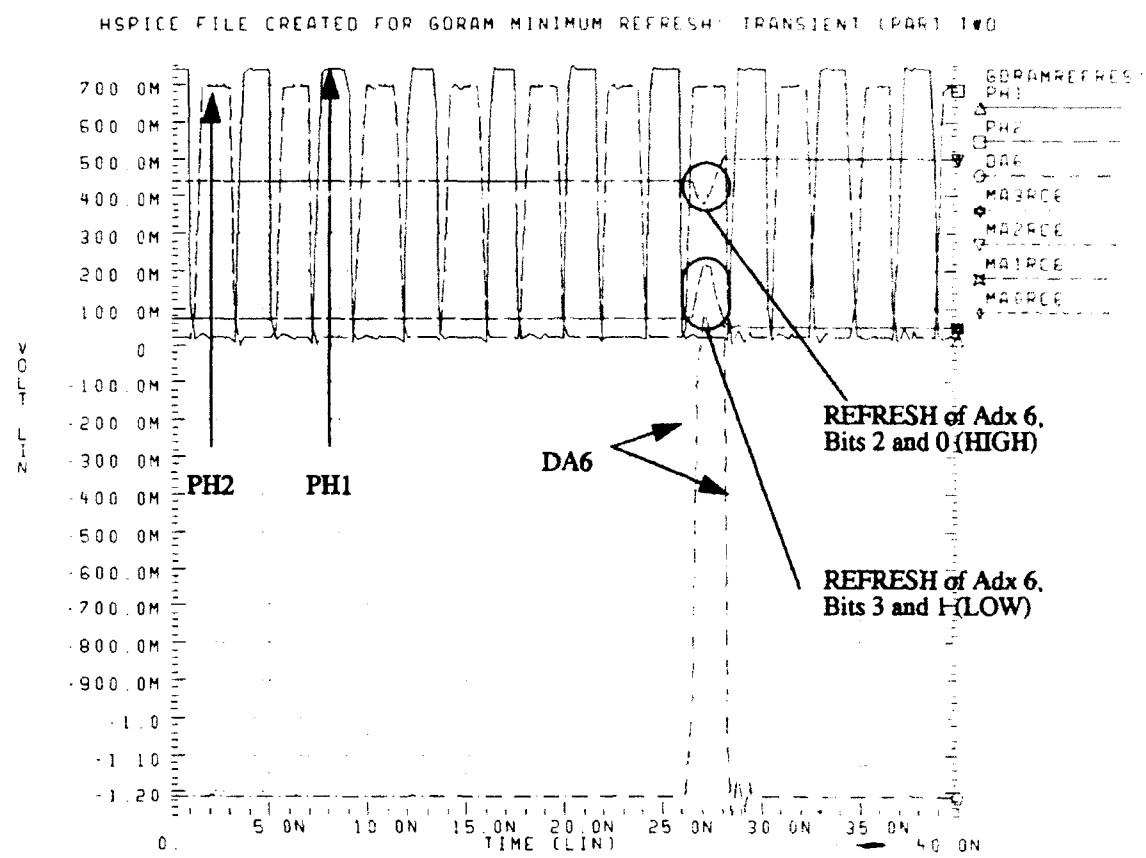


Figure 6.32 GaAs DRAM Minimum REFRESH Operation: Transient Analysis (Part Two)

The final figure of the GaAs DRAM minimum REFRESH operation, Figure 6.33 on page 252, demonstrates the assertion of the REFRESH signal, the assertion of the MREFRESH signal, and the associated activity of the memory status control signal, MBSY.

HSPICE FILE CREATED FOR GDRAM MINIMUM REFRESH TRANSIENT (PART THREE)

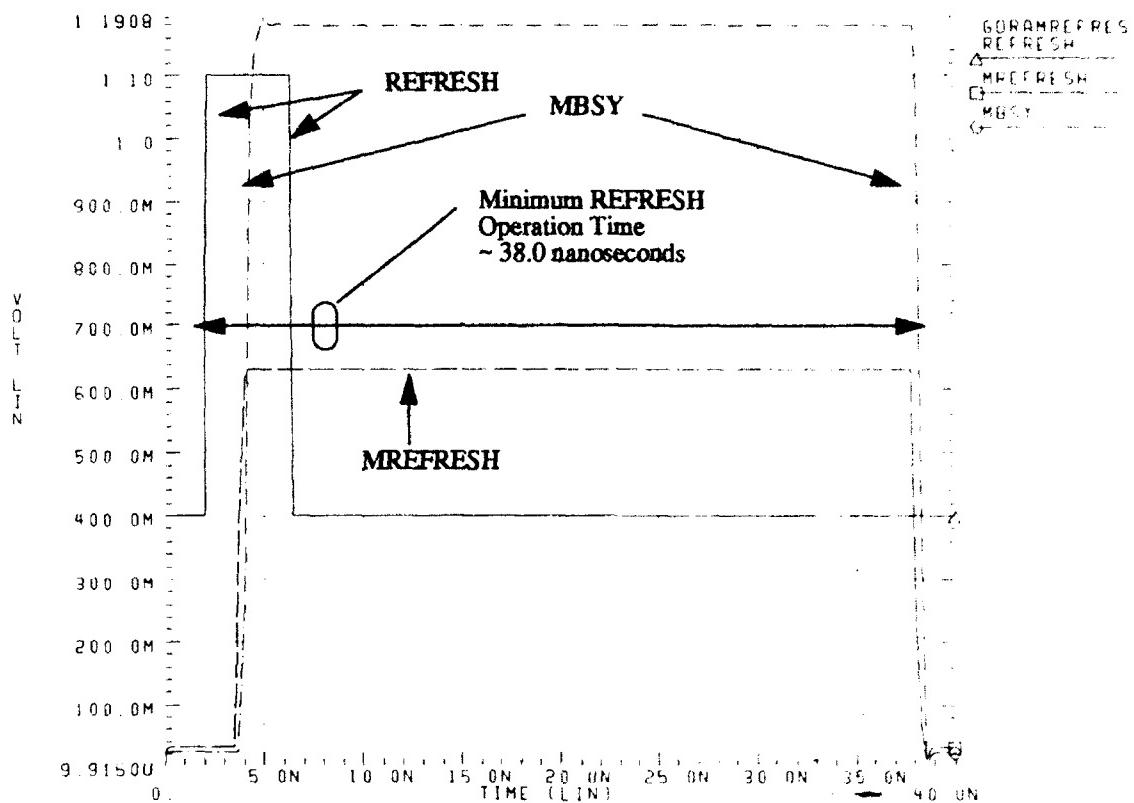


Figure 6.33 GaAs DRAM Minimum REFRESH Operation: Transient Analysis (Part Three)

In Figure 6.33, one may see the defining interval for a GaAs DRAM minimum REFRESH operation. This interval, defined to begin when the external control signal REFRESH is asserted and to end when the external memory status control signal MBSY is de-asserted, is approximately 38.0 nanoseconds. The HSPICE AVG function calculated an average power, ($p(V_{ds})$), of 2.45 watts over the minimum REFRESH operation target interval.

The final chapter of this report will present some observations on the design cycle followed by project conclusions.

VII. CONCLUSIONS

This final chapter will offer some observations on the design cycle followed by project conclusions.

A. THE DESIGN CYCLE

The design cycle for this project was rather long and full of twists and turns. The purpose of this chapter is to provide general information about the design paths chosen, traveled, discarded and re-traveled. Some mention of the Computer Aided Design (CAD) tools will be made and pitfalls will be disclosed.

1. Gallium Arsenide Circuit Design

Prior to commencing the research for the GaAs DRAM, a course in CMOS integrated circuit design and layout was completed. This course provided a useful background but in no way completely disclosed the necessary experience and procedures. Designing integrated circuits in CMOS is relatively "old news" these days, the leading edge of the CMOS technology is concentrated on greater and greater densities, such as the 64 megabit DRAM. Nevertheless, useful lessons may be learned and experience is gained.

The practical side of the design cycle included drawing out possible circuits and then testing these using the available simulator. After the circuits which operated correctly were integrated into the overall design, actual schematics were created for these circuits to facilitate both then present use and future reporting uses. A judicious choice of schematic editors, with an eye towards one day incorporating these same drawings directly into the future report was in order. However, the choices for the schematic editor were limited to the only one that was available. Much time along the path to the final design was invested in creating and updating schematic drawings and block diagrams. Unfortunately, as is sometimes the case, the only schematic editor which was available at the time did not have the facility to create postscript files that could then be later incorporated into the report. This lack of postscript capability was not noticed until much later and all the schematic drawings and block diagram drawings previously created and updated had to be redrawn.

The actual design of the GaAs DRAM occurred slowly because of the learning curve associated with designing in gallium arsenide. Whereas the design of CMOS logic elements is discussed in excruciating detail in any number of text books, the basic material necessary to design gallium arsenide logic elements is in short supply and what is available is frequently too advanced to be easily understood by students of GaAs. The main reference used to facilitate the GaAs DRAM design is the very comprehensive text written by

Messrs. Butler and Long of University of California, Santa Barbara campus [Ref. 10]. Easily the best GaAs text found and used nearly exclusively as it covers, but is not limited to, such topics as device physics, use of circuit simulators, and layout procedures.

2. Gallium Arsenide Circuit Simulation and Testing

The first step in this design cycle was designing basic GaAs logic elements and then testing these using whichever circuit simulator one could find that incorporated GaAs device libraries. Some mention of these device libraries is in order. Designing in gallium arsenide requires a circuit simulator such as SPICE to test the target circuits. Initially SPICE version 3G (SPICE3G) was used as it was the only simulator available. The libraries for GaAs MESFETs in SPICE3G are adequate but suffer from having no GaAs second order effects modeled. The most important GaAs second order effects concerning the GaAs DRAM are subthreshold current and substrate leakage current. The reason that these two gallium arsenide second order effects are so important is that both have direct effects on using GaAs MESFETs for charge storage. See [Ref. 10:pp. 114 - 120] for a thorough discussion of both of these second order effects. Lacking the second order effects, SPICE3G yielded very optimistic results with regard to the amount of time that a charge was maintained on a capacitor.

The final goal of the GaAs DRAM design cycle was fabrication and to this end, it was determined that MOSIS would provide funding to fabricate through Vitesse. It was further discovered that Vitesse has configured or customized SPICE version 3G to incorporate more accurate GaAs models, this version of SPICE will be referred to as Vitesse SPICE (VSPICE). The design cycle graduated to using VSPICE hoping to achieve more realistic results using the improved VSPICE GaAs libraries. Results achieved through VSPICE still indicated very optimistic charge storage time. This is because VSPICE, like SPICE3G, does not model the GaAs second order effects of subthreshold current and substrate leakage current.

It was at this time in the GaAs DRAM design cycle that the modeling and selection of the charge storage element occurred. The candidates for the charge storage element were a parallel plate capacitor, the gate of a E/D MESFET, or an E/D MESFET back-connected as a diode. The eventual choice was the parallel plate capacitor based upon test results. For a thorough discussion of various results obtained for each of the aforementioned charge storage elements, see [Ref. 8:pp. 3 - 8]. The selection of the charge storage element for the GaAs DRAM was based upon test results obtained using circuit simulators that did not model the second order effects. Were HSPICE (from Meta Software) available at the Naval Postgraduate School at the time of the charge storage element selection, a different choice may have occurred. This is reported in [Ref.

8:pp. 3 - 8]. HSPICE is the next generation circuit simulator, it has extensive libraries including the most important GaAs second order effects, it has improved convergence algorithms and memory management, and finally, a vastly improved user interface.

All the work that occurred prior to the arrival of HSPICE was re-tested using HSPICE (with its associated Vitesse HGaAs3 models) and while this was fairly time consuming, it was believed that the results obtained would now be the closest possible to reality. VSPICE and SPICE3G were not used again. The charge storage results obtained from HSPICE were encouraging but vastly different from those obtained using SPICE3G and VSPICE. The point of the discussion is the incorrect tool will yield incorrect results every time.

3. Gallium Arsenide Layout and Testing

The next step in the design cycle was the tentative layout of these GaAs logic circuits. The only layout tool available was MAGIC using "edgaas" (1.2 micron) technology file. Layout is another example of the "you must know who before you do" syndrome. Prior to layout, it is necessary to know almost certainly which company will be fabricating the design as each fabrication facility operates with different sets of parameters. As the technology for GaAs fabrication improves, the parameters vary (e.g. generally the gate lengths of the MESFETs become shorter) and this information must be considered when actually laying out the chip. Vitesse had been selected as the fabrication facility so it was necessary to obtain the MAGIC technology file from Vitesse through MOSIS. The technology file contains fabrication process information such as minimum gate lengths, material routing and spacing, and material specifications.

After each GaAs logic circuit was laid out used MAGIC, it was extracted and tested using HSPICE with its associated Vitesse HGaAs3 models. It was during this time that attention should have been paid to power consumption and operating temperature, but alas, it was not. Nearly at the end of the layout procedure, it occurred that power consumption at the expected operating temperature needed to be considered for both the length and width of the power and ground busses. As expected, the power consumption of the circuits used required greater widths and lengths than the minimums which were routinely used in order to facilitate a dense layout. As previously mentioned, GaAs logic circuits are not physically symmetric (as CMOS circuits are generally) when laid out and this caused some difficulty during the process and optimization for density. Virtually the entire layout was re-worked to make room for the required sizes of the power and ground busses.

4. Gallium Arsenide Fabrication and Testing

The fabrication procedure as available to educational institutions such as the Naval Postgraduate School through MOSIS results in a sum of money being allocated by MOSIS to cover the entire costs of the

fabrication. Many factors are considered when planning the actual fabrication including type of package, number of pins, and size of actual chip real estate. Once the layout was complete, having adjusted it for the required power and ground busses, it was determined that the GaAs DRAM array of eight eight-bit words was too large for the amount of money allocated by MOSIS for fabrication by Vitesse. This required a further "down-sizing" of the GaAs DRAM array to eight four-bit words in order to make it fit on the chip real estate that could be purchased. Once the interior body of the chip was completely laid out, it was then necessary to place the emitter-coupled logic (ECL) input/output driver circuits on the signal pins and also apply the procedures for "bonding" the pads with metal four in accordance with the Vitesse fabrication process parameters.

The testing of the entire GaAs DRAM chip (pad to pad) was accomplished using HSPICE. It should be mentioned that although HSPICE was run on a SUN SPARCstation 2 with 32 megabytes of read/write memory, the simulation of the entire chip required many days to run and several hundred megabytes of disk storage. HSPICE has incorporated several improvements over SPICE3G and VSPICE to facilitate smaller output files by judiciously choosing a select number of nodes about which to record data but even using these techniques the simulation still required days to finish.

Once the final GaAs DRAM array size was determined and the chip was tested, a "cif" file was generated and sent over INTERNET to MOSIS which in turn sent it to Vitesse. The construction of a test platform and the testing of the fabricated GaAs DRAM array will be the subject of a follow-on thesis.

B. CONCLUSIONS

The design goals for the gallium arsenide DRAM were met. These goals included very short memory access times, the use of GaAs standard materials, standard GaAs fabrication techniques, simple control circuitry, and acceptable power consumption.

1. Access Times

The GaAs DRAM access times are remarkably short, even when compared to commercial SRAM. In the 1991 Vitesse Semiconductor Corporation GaAs device catalog, a typical GaAs 256X4 static RAM, constructed from E/D MESFET technology, has an access time of four nanoseconds while consuming 1.75 watts. The GaAs DRAM offers a minimum READ/WRITE access time of approximately 3.0 nanoseconds while consuming ~ 2.45 watts. Of course, the initial bit density of the GaAs DRAM is very low and the initial power consumption per bit is much higher. Also, the REFRESH operation requires approximately 38.0 nanoseconds and this is a very long time compared to the access time for a READ or WRITE. Additionally,

the required periodic interval for REFRESH is reported by Vagts [Ref. 8:p. 21] to be approximately three milliseconds. In a commercial DRAM, the refresh operation is typically accomplished approximately every four milliseconds using rows within two-dimensional arrays [Ref 9:p. 648]. This greatly reduces the amount of time required for commercial DRAM to refresh the contents of all its memory addresses. Were the commercial DRAM design and layout techniques applied to the GaAs DRAM, there is no reason why the results achieved would not be similar.

2. Power Consumption

The power values reported for the READ, WRITE, and REFRESH operations include power consumption of the entire chip for the target operation. The specific power consumption values for each of the major circuits are discussed in the previous chapter. The two largest consumers of V_{DS} power are the CLOCK and DREFRESH, as one might expect. Both of these circuits would be improved were power optimization techniques applied. Also, given that the topic design chip is only eight four-bit words, one could argue that the economies of scale would greatly diminish the power consumption per bit. Additionally, the support circuitry was designed with the intent to use eight data bits, however, as previously discussed, the data bit density was halved after control design was complete. Therefore, the physical size of the transistors could, in many cases, be reduced which would reduce the overall power consumption.

3. Control Circuitry

The simplicity utilized in the control design was intentional. Improvements may certainly be made to the control design and some could be considered mandatory. One such improvement would be a better design to handle the possible non-simultaneous assertion of two operation signals, such as READ then WRITE. Also, the incorporation of input data latches would simplify the design of the control circuitry.

LIST OF REFERENCES

1. Fouts, D. J., "Gallium Arsenide Digital IC Design," paper presented to Advanced VLSI Design Class, Naval Postgraduate School, Monterey, CA, 10 February 1992.
2. Toyoda, N., K. Kanazawa, T. Terada, M. Mochizuki, M. Hirose, Y. Ikawa, and A. Hojo, "A 256x4 Bit GaAs Static Ram," *IEEE GaAs IC Symposium*, pp. 86-87, 1983.
3. Mizoguchi, T., N. Toyoda, K. Kanazawa, Y. Ikawa, T. Terada, M. Mochizuki and A. Hojo, "A GaAs 4K Bit Static RAM With Normally-On and -Off Combination Circuit," *IEEE GaAs Symposium*, pp. 117-120, 1984.
4. Dungan, T.E., P.G. Neudeck, M.R. Melloch, and J.A. Cooper, "One-Transistor GaAs MESFET- and JFET-Accessed Dynamic RAM Cells for High-Speed Medium Density Applications," *IEEE Transactions on Electron Devices*, vol. 37, no. 7, pp. 1599-1607, July 1990.
5. Chen, C.L., W.D. Goodhue, and L.J. Mahoney, "GaAs/AlGaAs Dynamic Random Access Memory Cell," *Electronic Letters*, vol. 27, no. 15, pp. 1330-1332, 18 July 1991.
6. Stellwag, T.B., J.A. Cooper, Jr., and M.R. Melloch, "A Vertically Integrated GaAs Bipolar Dynamic RAM Cell with Storage Times of 4.5 h at Room Temperature," *IEEE Electron Device Letters*, vol. 13, no. 2, pp. 129-131, February 1992.
7. Neudeck, P.G., T.E. Dungan, M.R. Melloch, and J.A. Cooper, "Electrical Characterization of a JFET-Accessed GaAs Dynamic RAM Cell," *IEEE Electron Device Letters*, vol. 10, no. 11, November 1989.
8. Vagts, C. B., *A Single-Transistor Memory Cell and Sense Amplifier For A Gallium Arsenide Dynamic Random Access Memory*, Master's Thesis, Naval Postgraduate School, Monterey, California, December 1992.
9. Wakerly, J.F., *Digital Design Principles and Practices*, pp. 648, Prentice-Hall, Inc., 1990.
10. Long, S. L., and Butner, S. E., *Gallium Arsenide Digital Integrated Circuit Design*, McGraw-Hill Publishing Co., 1990.

APPENDIX A - HSPICE FILES

The HSPICE files are provided for a representative sample of the GaAs DRAM logic circuits. Abbreviated in the interest of brevity (as providing all listing files will result in an appendix length over 600 pages), this collection of listing files provides both the structure of the “*.sp” file and the information not specifically contained in any graph but listed separately in TABLE 4.1, “GaAs DRAM LOW-LEVEL CIRCUIT OPERATING CHARACTERISTICS,” on page 158. The listing files result from simulating the GaAs DRAM circuits with HSPICE.

A. Listing File for DINV Transient Analysis at 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)

```
***** hspice 9007d 19:27:27 23-jan93 sun
** hspice file created for circuit 'dinv'
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
* hspice dcfl standard load subcircuit
*      input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
* ***** hspice version *****
```

```

* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card
*.temp 85.0

* signal inputs
* next line is for dc transfer analysis
*vin 999 0

* next line is used to provide the test signal input for transient analysis
va0 101 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)

* main circuit
x0 101 102 888 0 dinv
x1 102 103 888 0 dinv
x2 103 106 888 0 dinv
x3 106 104 1 0 dinv $ element under test
x4 104 107 888 0 d2load $ test load

* measurement parameters

* next three lines are used for dc transfer analysis
*.dc vin 0.00 0.63 0.001
*.probe dc out/in=v(104,0)

* next two lines are used for transient analysis
.probe input=v(106) output=v(104)
.probe tran p(vds) p(va0) p(vload) power

* next 8 lines will calculate vmax vmin trise tfall and tdelay :transient analy
s
.meas tran vmax max v(104) from=2ns to=20ns
.meas tran vmin min v(104) from=2ns to=20ns
.meas tran tphl trig v(106) val='(vmax-vmin)*.5' td=2ns
+ rise=1 targ v(104) val='(vmax-vmin)*.5' td=2ns fall=1
.meas tran tphh trig v(106) val='(vmax-vmin)*.5' td=2ns
+ fall=1 targ v(104) val='(vmax-vmin)*.5' td=2ns rise=1
.meas tran trise trig v(104) val='vmin+0.1*vmax' td=2ns
+ rise=1 targ v(104) val='0.9*vmax' rise=1
.meas tran tfall trig v(104) val='0.9*vmax' td=2ns
+ fall=2 targ v(104) val='vmin+0.1*vmax' fall=2
.meas tran tdelay trig v(106) val=.2835 td=2ns fall=1
+ targ v(104) val=.2835 rise=1
.tran 50ps 20ns
.options scale=1e-06 brief=0 nopage measout post probe
.end
** hspice file created for circuit 'dinv'

```

```

***** circuit name directory
*****
circuit number to circuit name directory
number circuitname      definition multiplier
 0 main circuit
 1 x0.          dinv    1.00
 2 x1.          dinv    1.00
 3 x2.          dinv    1.00
 4 x3.          dinv    1.00
 5 x4.          d2load  1.00
 6 x4.x0.       dinv    1.00
 7 x4.x1.       dinv    1.00
Opening plot unit= 15
file=dinv.pa0

** hspice file created for circuit 'dinv'
***** operating point information  tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is 0.
node =voltage node =voltage node =voltage

+0:1   = 2.0000 0:101   = 63.0000m 0:102   = 658.6414m
+0:103  = 52.0534m 0:104   = 52.0545m 0:106   = 658.6893m
+0:107  = 1.9872 0:888   = 2.0000 5:5     = 1.9872

```

```

Opening plot unit= 16
file=dinv.tr0

** hspice file created for circuit 'dinv'
***** transient analysis      tnom= 25.000 temp= 25.000
*****
vmax      = 6.4062E-01 at= 4.8836E-09
           from= 2.0000E-09 to= 2.0000E-08
vmin      = 5.0543E-02 at= 1.7275E-08
           from= 2.0000E-09 to= 2.0000E-08
tphl      = 1.0795E-10 targ= 8.5989E-09 trig= 8.4910E-09
tplh      = 7.0997E-11 targ= 4.4733E-09 trig= 4.4023E-09
trise     = 3.5183E-10 targ= 4.7526E-09 trig= 4.4007E-09
tfall     = 1.3037E-10 targ= 1.7061E-08 trig= 1.6931E-08
tdelay    = 6.2566E-11 targ= 4.4672E-09 trig= 4.4046E-09

***** job concluded
total cpu time      14.08 seconds
job started at 19:27:27 23-jan93
job ended at 19:27:57 23-jan93

```

I am done with dinv.sp

Sat Jan 23 19:27:59 PST 1993

B. Listing File for D4NOR Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)

```
***** h s p i c e  9007d      6:49:1 25-jan93 sun
** hspice file created for circuit d4nor: transient&power @ 25.0c
***** copyright 1990 meta-software inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
* hspice dcfl 4-input nor subcircuit
*      ina, inb, inc, ind, output, power, ground
.subckt d4nor 1 2 3 4 5 6 7
* d g s b
j0 6 5 5 7 jfet16 l=1.2 w=6.0
j1 5 1 7 7 jfet04 l=1.2 w=96.0
j2 5 2 7 7 jfet04 l=1.2 w=96.0
j3 5 3 7 7 jfet04 l=1.2 w=96.0
j4 5 4 7 7 jfet04 l=1.2 w=96.0
.ends d4nor
*****
* hspice dcfl standard load subcircuit
*      input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
```

* power supplies

vds 1 0 dc 2.0v \$ element under test power supply

vload 888 0 dc 2.0v \$ test load power supply

* temperature card

*.temp 85.0

* signal inputs

* next line is for dc transfer analysis

*vin 999 0

* next three lines used to provide test signal inputs for transient analysis

va 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)

vb 101 0 pulse(0.063 0.63 8400ps 100ps 100ps 8200ps 16800ps)

vc 102 0 pulse(0.063 0.63 16800ps 100ps 100ps 16600ps 33600ps)

vd 103 0 pulse(0.063 0.63 33600ps 100ps 100ps 33400ps 67200ps)

* main circuit

* ina inb inc ind out pwr gnd subname

x3 100 101 102 103 104 1 0 d4nor \$ element under test

x4 104 107 888 0 d2load \$ test load

* measurement parameters

* next two lines are used for dc transfer analysis

*.dc vin 0.00 0.63 0.001

*.probe dc out/in=v(104.0)

* next two lines are used for transient analysis

.probe ina=v(100) inb=v(101) inc=v(102) ind=v(103) output=v(104)

.probe tran p(vds) p(vload) power

* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis

.meas tran vmax max v(104) from=2ns to=80ns

.meas tran vmin min v(104) from=2ns to=80ns

* next line is adjustment necessary to facilitate measuring tfall. if

* vmin is used in tfall calc, then the tfall calculation fails as the is a larg

e

* negative voltage spike when the four input mesfets switch from

* all on to all off and this skews the targ parameter. notice that

* vmin2 is used only in the tfall calculation line.

.meas tran vmin2 find v(104) at=64ns

.meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=2ns

+ rise=1 targ v(104) val='(vmax-vmin)*.5' td=2ns fall=1

.meas tran tpls trig v(103) val='(vmax-vmin)*.5' td=2ns

+ fall=1 targ v(104) val='(vmax-vmin)*.5' td=62ns rise=1

.meas tran trise trig v(104) val='vmin+0.1*vmax' td=62ns

+ rise=1 targ v(104) val='0.9*vmax' rise=1

.meas tran tfall trig v(104) val='0.9*vmax' td=65ns

+ fall=1 targ v(104) val='vmin2+0.1*vmax' fall=1

```

.meas tran tdelay trig v(103) val=.2835 td=62ns fall=1
+ targ v(104) val=.2835 rise=1
.tran 150ps 80ns
.options scale=1e-06 brief=0 nopage measout post probe
.end
** hspice file created for circuit d4nor: transient&power @ 25.0c
***** circuit name directory
*****
circuit number to circuit name directory
number circuitname definition multiplier
 0 main circuit
 1 x3.          d4nor    1.00
 2 x4.          d2load   1.00
 3 x4.x0.       dinv     1.00
 4 x4.x1.       dinv     1.00
Opening plot unit= 15
file=d4nor1.pa0

** hspice file created for circuit d4nor: transient&power @ 25.0c
***** operating point information  tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is 0.
node =voltage node =voltage node =voltage

+0:1    = 2.0000 0:100    = 63.0000m 0:101    = 63.0000m
+0:102  = 63.0000m 0:103    = 63.0000m 0:104    = 635.9439m
+0:107  = 53.1628m 0:888    = 2.0000 2:5    = 53.1628m

```

```

Opening plot unit= 16
file=d4nor1.tr0

** hspice file created for circuit d4nor: transient&power @ 25.0c
***** transient analysis      tnom= 25.000 temp= 25.000
*****
vmax      = 6.3802E-01 at= 6.7826E-08
           from= 2.0000E-09 to= 8.0000E-08
vmin      = -5.3923E-02 at= 6.7200E-08
           from= 2.0000E-09 to= 8.0000E-08
vmin2     = 1.9445E-02
tpul     = 6.1325E-11 targ= 4.3112E-09 trig= 4.2499E-09
tplh     = 2.1956E-10 targ= 6.7370E-08 trig= 6.7150E-08
trise    = 4.5618E-10 targ= 6.7673E-08 trig= 6.7217E-08
tfall    = 2.0223E-10 targ= 7.1664E-08 trig= 7.1461E-08
tdelay   = 1.5877E-10 targ= 6.7320E-08 trig= 6.7161E-08

***** job concluded
total cpu time    16.01 seconds
job started at 6:49:1 25-jan93

```

job ended at 6:49:36 25-jan93

I am done with d4nor1.sp
Mon Jan 25 06:49:38 PST 1993

C. Listing File for DD3NAND Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)

```
***** h s p i c e  9007d      6:26:19 2-feb93 sun
** hspice file created for circuit dd3nand: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv  1  2  3  4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
* hspice dcfl 3-input demorgan nand subcircuit
*      ina, inb, inc, output, power, ground
.subckt dd3nand  1  2  3  4  5  6
x0 1    10 5 6 dinv
x1 2    11 5 6 dinv
x2 3    12 5 6 dinv
x3 10 11 12 13 5 6 d3nor
x4 13  4 5 6 dinv
.ends dd3nand
*****
* hspice dcfl 3-input nor subcircuit
*      ina, inb, inc, output, power, ground
.subckt d3nor   1  2  3  4  5  6
* d g s b
j0 5 4 4 6 jfet16 l=1.2 w=6.0
j1 4 1 6 6 jfet04 l=1.2 w=96.0
j2 4 2 6 6 jfet04 l=1.2 w=96.0
```

```

j3 4 3 6 6 jfet04 l=1.2 w=96.0
.ends d3nor
*****
*****
* hspice dcfl standard load subcircuit
*      input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card
*.temp 85.0

* signal inputs
* next line is for dc transfer analysis
*vin 999 0

* next three lines used to provide test signal inputs for transient analysis
va 101 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vb 102 0 pulse(0.063 0.63 8400ps 100ps 100ps 8200ps 16800ps)
vc 103 0 pulse(0.063 0.63 16800ps 100ps 100ps 16600ps 33600ps)

* main circuit
* ina inb inc out pwr gnd subname
x3 101 102 103 104 1 0 dd3nand $ element under test
x4 104 107 888 0 d2load $ test load

* measurement parameters

* next two lines are used for dc transfer analysis
*.dc vin 0.00 0.63 0.001
*.probe dc out/in=v(104.0)

* next two lines are used for transient analysis
.probe ina=v(101) inb=v(102) inc=v(103) output=v(104)
.probe tran p(vds) p(vload) power

* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis
.meas tran vmax max v(104) from=2ns to=42ns
.meas tran vmin min v(104) from=2ns to=42ns
.meas tran tphi trig v(101) val='(vmax-vmin)*.5' td=2ns

```

```

+ rise=1 targ v(104) val='(vmax-vmin)*.5' td=2ns fall=1
.meas tran tphy trig v(103) val='(vmax-vmin)*.5' td=2ns
+ fall=1 targ v(104) val='(vmax-vmin)*.5' td=32ns rise=1
.meas tran trise trig v(104) val='vmin+0.1*vmax' td=32ns
+ rise=1 targ v(104) val='0.9*vmax' rise=1
.meas tran tfall trig v(104) val='0.9*vmax' td=25ns
+ fall=1 targ v(104) val='vmin+0.1*vmax' fall=1
.meas tran tdelay trig v(103) val=.2835 td=32ns fall=1
+ targ v(104) val=.2835 rise=1
.tran 100ps 42ns
.options scale=1e-06 brief=0 nopage measout post probe
.end
** hspice file created for circuit dd3nand: transient&power @ 25.0c
***** circuit name directory
*****

```

circuit number to circuit name directory
 number circuitname definition multiplier

0	main circuit		
1	x3.	dd3nand	1.00
2	x4.	d2load	1.00
3	x3.x0.	dinv	1.00
4	x3.x1.	dinv	1.00
5	x3.x2.	dinv	1.00
6	x3.x3.	d3nor	1.00
7	x3.x4.	dinv	1.00
8	x4.x0.	dinv	1.00
9	x4.x1.	dinv	1.00

Opening plot unit= 15
 file=dd3nand1.pa0

```

** hspice file created for circuit dd3nand: transient&power @ 25.0c
***** operating point information  tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is 0.
  node =voltage  node =voltage  node =voltage

```

```

+0:1    = 2.0000 0:101    = 63.0000m 0:102    = 63.0000m
+0:103   = 63.0000m 0:104    = 636.6116m 0:107    = 53.0853m
+0:888   = 2.0000 1:10    = 651.4791m 1:11    = 651.4791m
+1:12    = 651.4791m 1:13    = 26.2297m 2:5    = 53.0853m

```

Opening plot unit= 16
 file=dd3nand1.tr0

```

** hspice file created for circuit dd3nand: transient&power @ 25.0c
***** transient analysis          tnom= 25.000 temp= 25.000
*****
  vmax      = 6.4002E-01  at= 3.4050E-08

```

```

from= 2.0000E-09 to= 4.2000E-08
vmin      = 5.1063E-02 at= 2.9925E-08
from= 2.0000E-09 to= 4.2000E-08
tphl      = 2.5424E-08 targ= 2.9665E-08 trig= 4.2408E-09
tplh      = 1.3913E-10 targ= 3.3698E-08 trig= 3.3559E-08
trise     = 3.3657E-10 targ= 3.3969E-08 trig= 3.3633E-08
tfall     = 1.3463E-10 targ= 2.9722E-08 trig= 2.9588E-08
tdelay    = 1.3311E-10 targ= 3.3694E-08 trig= 3.3561E-08

```

***** job concluded

total cpu time 18.28 seconds

job started at 6:26:19 2-feb93

job ended at 6:27:15 2-feb93

I am done with dd3nand1.sp

Tue Feb 2 06:27:16 PST 1993

D. Listing File for DD4AND Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
 lic: license granted by the license server for hspice
 lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
 reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
 setting user memory from environment var to 250000 words. (2000000 bytes)

```

***** h s p i c e 9007d    7:4:18 26-jan93 sun
** hspice file created for circuit dd4and: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site: -----
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
* hspice dcfl 4-input nor subcircuit
*      ina, inb, inc, ind, output, power, ground
.subckt d4nor 1 2 3 4 5 6 7
* d g s b
j0 6 5 5 7 jfet16 l=1.2 w=6.0
j1 5 1 7 7 jfet04 l=1.2 w=96.0

```

```

j2 5 2 7 7 jfet04 l=1.2 w=96.0
j3 5 3 7 7 jfet04 l=1.2 w=96.0
j4 5 4 7 7 jfet04 l=1.2 w=96.0
.ends d4nor
*****
*****
* hspice dcfl 4-input demorgan and subcircuit
*      ina, inb, inc, ind, output, power, ground
.subckt dd4and 1 2 3 4 5 6 7
x0 1      10 6 7 dinv
x1 2      11 6 7 dinv
x2 3      12 6 7 dinv
x3 4      13 6 7 dinv
x4 10 11 12 13 5 6 7 d4nor
.ends dd4and
*****
*****
* hspice dcfl standard load subcircuit
*      input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card
*.temp 85.0

* signal inputs
* next line is for dc transfer analysis
*vin 999 0

* next three lines used to provide test signal inputs for transient analysis
va 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vb 101 0 pulse(0.063 0.63 8400ps 100ps 100ps 8200ps 16800ps)
vc 102 0 pulse(0.063 0.63 16800ps 100ps 100ps 16600ps 33600ps)
vd 103 0 pulse(0.063 0.63 33600ps 100ps 100ps 33400ps 67200ps)

* main circuit
* ina inb inc ind out pwr gnd subname
x3 100 101 102 103 104 1 0 dd4and $ element under test
x4 104      107 888 0 d2load $ test load

* measurement parameters

```

```

* next two lines are used for dc transfer analysis
*.dc vin 0.00 0.63 0.001
*.probe dc out/in=v(104.0)

* next two lines are used for transient analysis
.probe ina=v(100) inb=v(101) inc=v(102) ind=v(103) output=v(104)
.probe tran p(vds) p(vload) power

* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis
.meas tran vmax max v(104) from=2ns to=80ns
.meas tran vmin min v(104) from=2ns to=80ns
* next line is adjustment necessary to facilitate measuring tfall. if
* vmin is used in tfall calc, then the tfall calculation fails as the is a larg
e
* negative voltage spike when the four input mesfets switch from
* all on to all off and this skews the targ parameter. notice that
* vmin2 is used only in the tfall calculation line.
.meas tran vmin2 find v(104) at=64ns
.meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=62ns
+ fall=1 targ v(104) val='(vmax-vmin)*.5' td=2ns fall=1
.meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=60ns
+ rise=1 targ v(104) val='(vmax-vmin)*.5' td=60ns rise=1
.meas tran trise trig v(104) val='vmin+0.1*vmax' td=2ns
+ rise=1 targ v(104) val='0.9*vmax' rise=1
.meas tran tfall trig v(104) val='0.9*vmax' td=2ns
+ fall=1 targ v(104) val='vmin+0.1*vmax' fall=1
.meas tran tdelay trig v(100) val=.2835 td=60ns rise=1
+ targ v(104) val=.2835 rise=1
.tran 150ps 80ns
.options scale=1e-06 brief=0 nopage measout post probe
.end
** hspice file created for circuit dd4and: transient&power @ 25.0c
***** circuit name directory
*****
circuit number to circuit name directory
number circuitname           definition multiplier
0 main circuit
 1 x3.          dd4and    1.00
 2 x4.          d2load    1.00
 3 x3.x0.       dinv      1.00
 4 x3.x1.       dinv      1.00
 5 x3.x2.       dinv      1.00
 6 x3.x3.       dinv      1.00
 7 x3.x4.       d4nor     1.00
 8 x4.x0.       dinv      1.00
 9 x4.x1.       dinv      1.00
Opening plot unit= 15
file=dd4and1.pa0

```

** hspice file created for circuit dd4and: transient&power @ 25.0c

```
***** operating point information tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is 0.
node =voltage node =voltage node =voltage

+0:1 = 2.0000 0:100 = 63.0000m 0:101 = 63.0000m
+0:102 = 63.0000m 0:103 = 63.0000m 0:104 = 23.1758m
+0:107 = 1.9925 0:888 = 2.0000 1:10 = 650.4087m
+1:11 = 650.4087m 1:12 = 650.4087m 1:13 = 650.4087m
+2:5 = 1.9925
```

Opening plot unit= 16
file=dd4and1.tr0

```
** hspice file created for circuit dd4and: transient&power @ 25.0c
***** transient analysis tnom= 25.000 temp= 25.000
*****
vmax = 6.4077E-01 at= 6.7150E-08
from= 2.0000E-09 to= 8.0000E-08
vmin = 1.6595E-02 at= 7.5700E-08
from= 2.0000E-09 to= 8.0000E-08
vmin2 = 6.3620E-01
tphl = 7.5761E-11 targ= 6.7232E-08 trig= 6.7156E-08
tplh = 1.5859E-10 targ= 6.3203E-08 trig= 6.3044E-08
trise = 4.1758E-10 targ= 6.3491E-08 trig= 6.3074E-08
tfall = 1.0060E-10 targ= 6.7281E-08 trig= 6.7181E-08
tdelay = 1.3853E-10 targ= 6.3177E-08 trig= 6.3039E-08
-
***** job concluded
total cpu time 24.41 seconds
job started at 7: 4:18 26-jan93
job ended at 7: 5:11 26-jan93
```

I am done with dd4and1.sp
Tue Jan 26 07:05:12 PST 1993

E. Listing File for DD4OR Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)

```
***** h s p i c e 9007d 21:2:42 26-jan93 sun
** hspice file created for circuit dd4or: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
```

```

***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
***** hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
***** hspice dcfl 4-input nor subcircuit
*      ina, inb, inc, ind, output, power, ground
.subckt d4nor 1 2 3 4 5 6 7
* d g s b
j0 6 5 5 7 jfet16 l=1.2 w=6.0
j1 5 1 7 7 jfet04 l=1.2 w=96.0
j2 5 2 7 7 jfet04 l=1.2 w=96.0
j3 5 3 7 7 jfet04 l=1.2 w=96.0
j4 5 4 7 7 jfet04 l=1.2 w=96.0
.ends d4nor
*****
***** subcircuit dcfl 4-input or
*      ina inb inc ind output power ground
.subckt dd4or 1 2 3 4 5 6 7
* ina inb inc ind out pwr gnd subname
x0 1 2 3 4 8 6 7 d4nor
x1 8      5 6 7 dinv
.ends dd4or
*****
***** hspice dcfl standard load subcircuit
*      input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

```

```

* temperature card
*.temp 85.0

* signal inputs
* next line is for dc transfer analysis
*vin 999 0

* next three lines used to provide test signal inputs for transient analysis
va 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vb 101 0 pulse(0.063 0.63 8400ps 100ps 100ps 8200ps 16800ps)
vc 102 0 pulse(0.063 0.63 16800ps 100ps 100ps 16600ps 33600ps)
vd 103 0 pulse(0.063 0.63 33600ps 100ps 100ps 33400ps 67200ps)

* main circuit
* ina inb inc ind out pwr gnd subname
x3 100 101 102 103 104 1 0 dd4or $ element under test
x4 104 107 888 0 d2load $ test load

* measurement parameters

* next two lines are used for dc transfer analysis
*.dc vin 0.00 0.63 0.001
*.probe dc out/in=v(104,0)

* next two lines are used for transient analysis
.probe ina=v(100) inb=v(101) inc=v(102) ind=v(103) output=v(104)
.probe tran p(vds) p(vload) power

* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis
.meas tran vmax max v(104) from=2ns to=80ns
.meas tran vmin min v(104) from=2ns to=80ns
* next line is adjustment necessary to facilitate measuring tfall. if
* vmin is used in tfall calc, then the tfall calculation fails as the is a larg
e
* negative voltage spike when the four input mesfets switch from
* all on to all off and this skews the targ parameter. notice that
* vmin2 is used only in the tfall calculation line.
.meas tran vmin2 find v(104) at=64ns
.meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=62ns
+ fall=1 targ v(104) val='(vmax-vmin)*.5' td=2ns fall=1
.meas tran tpbh trig v(100) val='(vmax-vmin)*.5' td=70ns
+ rise=1 targ v(104) val='(vmax-vmin)*.5' td=70ns rise=1
.meas tran trise trig v(104) val='vmin+0.1*vmax' td=2ns
+ rise=1 targ v(104) val='0.9*vmax' rise=1
.meas tran tfall trig v(104) val='0.9*vmax' td=2ns
+ fall=1 targ v(104) val='vmin+0.1*vmax' fall=1
.meas tran tdelay trig v(100) val=.2835 td=70ns rise=1
+ targ v(104) val=.2835 td=70ns rise=1
.tran 150ps 80ns
.options scale=1e-06 brief=0 nopage measout post probe

```

```

.end
** hspice file created for circuit dd4or: transient&power @ 25.0c
***** circuit name directory
*****
circuit number to circuit name directory
number circuitname      definition multiplier
 0 main circuit
 1 x3.          dd4or    1.00
 2 x4.          d2load   1.00
 3 x3.x0.       d4nor    1.00
 4 x3.x1.       dinv     1.00
 5 x4.x0.       dinv     1.00
 6 x4.x1.       dinv     1.00
Opening plot unit= 15
file=dd4or1.pa0

** hspice file created for circuit dd4or: transient&power @ 25.0c
***** operating point information  tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is  0.
  node =voltage  node =voltage  node =voltage

+0:1  = 2.0000 0:100  = 63.0000m 0:101  = 63.0000m
+0:102 = 63.0000m 0:103  = 63.0000m 0:104  = 52.0403m
+0:107 = 1.9872 0:888  = 2.0000 1:8    = 658.0337m
+2:5   = 1.9872

Opening plot unit= 16
file=dd4or1.tr0

** hspice file created for circuit dd4or: transient&power @ 25.0c
***** transient analysis        tnom= 25.000 temp= 25.000
*****
  vmax   = 6.4095E-01  at= 3.3625E-08
  from= 2.0000E-09  to= 8.0000E-08
  vmin   = 5.1203E-02  at= 6.7750E-08
  from= 2.0000E-09  to= 8.0000E-08
  vmin2  = 6.3663E-01
  tphi   = 2.5787E-10 targ= 6.7417E-08 trig= 6.7159E-08
  tphl   = 1.2195E-10 targ= 7.1563E-08 trig= 7.1441E-08
  trise  = 3.5080E-10 targ= 4.6374E-09 trig= 4.2866E-09
  tfall  = 1.6879E-10 targ= 6.7496E-08 trig= 6.7328E-08
  tdelay = 1.1768E-10 targ= 7.1557E-08 trig= 7.1439E-08

***** job concluded
total cpu time    17.67 seconds
job started at 21: 2:42 26-jan93
job ended at 21: 3:18 26-jan93

```

I am done with dd4or1.sp
Tue Jan 26 21:03:20 PST 1993

F. Listing File for CPDFF Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)

```
***** hspice 9007d 8:43:4 2-feb93 sun
** hspice file created for circuit cpdff: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
* subcircuit hspice dcfl /clear d flip flop
* wakerly pg 363 - 31july 1992
*** d clk /clr q /q power ground
.subckt cpdff 1 2 3 4 5 6 7
x0 12 10 9 6 7 dd2nand
x1 9 3 2 10 6 7 dd3nand
x2 10 2 12 11 6 7 dd3nand
x3 11 3 1 12 6 7 dd3nand
x4 10 5 4 6 7 dd2nand
x5 4 3 11 5 6 7 dd3nand
.ends cpdff
*****
* hspice dcfl 3-input nor subcircuit
* ina, inb, inc, output, power, ground
.subckt d3nor 1 2 3 4 5 6
* d g s b
j0 5 4 4 6 jfet16 l=1.2 w=6.0
j1 4 1 6 6 jfet04 l=1.2 w=96.0
j2 4 2 6 6 jfet04 l=1.2 w=96.0
j3 4 3 6 6 jfet04 l=1.2 w=96.0
.ends d3nor
*****
* hspice dcfl 3-input demorgan nand subcircuit
* ina, inb, inc, output, power, ground
.subckt dd3nand 1 2 3 4 5 6
x0 1 10 5 6 dinv
x1 2 11 5 6 dinv
```

```

x2 3    12 5 6 dinv
x3 10 11 12 13 5 6 d3nor
x4 13    4 5 6 dinv
.ends dd3nand
*****
*****
* hspice dcfl 2-input nor subcircuit
*      ina, inb, output, power, ground
.subckt d2nor  1  2  3  4  5
* d g s b
j0 4 3 3 5 jfet16 l=1.2 w=6.0
j1 3 1 5 5 jfet04 l=1.2 w=96.0
j2 3 2 5 5 jfet04 l=1.2 w=96.0
.ends d2nor
*****
* hspice dcfl 2-input demorgan nand subcircuit
*      ina, inb, output, power, ground
.subckt dd2nand 1  2  3  4  5
x0 1    10 4 5 dinv
x1 2    11 4 5 dinv
x2 10 11 12 4 5 d2nor
x3 12    3  4 5 dinv
.ends dd2nand
*****
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv  1   2   3   4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
*****
* hspice dcfl standard load subcircuit
*      input, output, power, ground
.subckt d2load 1   2   3   4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card
*.temp 85.0

```

* signal inputs
 * next line is for dc transfer analysis
 *vin 999 0

 * next three lines used to provide test signal inputs for transient analysis
 va 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
 vb 101 0 pulse(0.063 0.63 8400ps 100ps 100ps 8200ps 16800ps)
 vc 102 0 pulse(0.063 0.63 16800ps 100ps 100ps 16600ps 33600ps)

* main circuit
 * d clk clr q /q power ground
 x0 101 100 102 104 105 1 0 cpdff \$ element under test
 x1 104 107 888 0 d2load \$ test load
 x2 105 108 888 0 d2load \$ test load
 * measurement parameters

* next two lines are used for dc transfer analysis
 *.dc vin 0.00 0.63 0.001
 *.probe dc out/in=v(104,0)

* next two lines are used for transient analysis
 .probe din=v(101) clk=v(100) clr=v(102) q=v(104) qnot=v(105)
 .probe tran p(vds) p(vload) power

* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis
 .meas tran vmax max v(104) from=2ns to=40ns
 .meas tran vmin min v(104) from=2ns to=40ns
 .meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=27ns
 + rise=1 targ v(105) val='(vmax-vmin)*.5' td=2ns fall=1
 .meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=27ns
 + rise=1 targ v(104) val='(vmax-vmin)*.5' td=2ns rise=1
 .meas tran trise trig v(104) val='vmin+0.1*vmax' td=2ns
 + rise=1 targ v(104) val='0.9*vmax' rise=1
 .meas tran tfall trig v(105) val='0.9*vmax' td=2ns
 + fall=1 targ v(105) val='vmin+0.1*vmax' fall=1
 .meas tran tdelay trig v(100) val=.2835 td=27ns rise=1
 + targ v(105) val=.2835 td=20ns fall=1
 .tran 50ps 40ns
 .options scale=1e-06 brief=0 nopage measout post probe
 .end

** hspice file created for circuit cpdff: transient&power @ 25.0c
 ***** circuit name directory

circuit number to circuit name directory
 number circuitname definition multiplier
 0 main circuit
 1 x0. cpdff 1.00
 2 x1. d2load 1.00
 3 x2. d2load 1.00

4 x0.x0.	dd2nand	1.00
5 x0.x1.	dd3nand	1.00
6 x0.x2.	dd3nand	1.00
7 x0.x3.	dd3nand	1.00
8 x0.x4.	dd2nand	1.00
9 x0.x5.	dd3nand	1.00
10 x1.x0.	dinv	1.00
11 x1.x1.	dinv	1.00
12 x2.x0.	dinv	1.00
13 x2.x1.	dinv	1.00
14 x0.x0.x0.	dinv	1.00
15 x0.x0.x1.	dinv	1.00
16 x0.x0.x2.	d2nor	1.00
17 x0.x0.x3.	dinv	1.00
18 x0.x1.x0.	dinv	1.00
19 x0.x1.x1.	dinv	1.00
20 x0.x1.x2.	dinv	1.00
21 x0.x1.x3.	d3nor	1.00
22 x0.x1.x4.	dinv	1.00
23 x0.x2.x0.	dinv	1.00
24 x0.x2.x1.	dinv	1.00
25 x0.x2.x2.	dinv	1.00
26 x0.x2.x3.	d3nor	1.00
27 x0.x2.x4.	dinv	1.00
28 x0.x3.x0.	dinv	1.00
29 x0.x3.x1.	dinv	1.00
30 x0.x3.x2.	dinv	1.00
31 x0.x3.x3.	d3nor	1.00
32 x0.x3.x4.	dinv	1.00
33 x0.x4.x0.	dinv	1.00
34 x0.x4.x1.	dinv	1.00
35 x0.x4.x2.	d2nor	1.00
36 x0.x4.x3.	dinv	1.00
37 x0.x5.x0.	dinv	1.00
38 x0.x5.x1.	dinv	1.00
39 x0.x5.x2.	dinv	1.00
40 x0.x5.x3.	d3nor	1.00
41 x0.x5.x4.	dinv	1.00

Opening plot unit= 15

file=cpdff1.pa0

```
** hspice file created for circuit cpdff: transient&power @ 25.0c
***** operating point information tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is 0.
node =voltage node =voltage node =voltage
```

```
+ 0:1 = 2.0000 0:100 = 63.0000m 0:101 = 63.0000m
+ 0:102 = 63.0000m 0:104 = 52.0504m 0:105 = 624.0322m
+ 0:107 = 1.9872 0:108 = 54.9711m 0:888 = 2.0000
```

```

+ 1:9  = 52.0506m 1:10  = 624.0441m 1:11  = 636.5449m
+ 1:12 = 636.5992m 2:5  = 1.9872 3:5  = 54.9711m
+ 4:10 = 53.0867m 4:11  = 54.9689m 4:12  = 658.5204m
+ 5:10 = 651.5268m 5:11  = 651.4803m 5:12  = 651.4803m
+ 5:13 = 26.2332m 6:10  = 54.9689m 6:11  = 658.6219m
+ 6:12 = 53.0867m 6:13  = 51.9641m 7:10  = 53.0929m
+ 7:11 = 653.4945m 7:12  = 653.4945m 7:13  = 32.4207m
+ 8:10 = 54.9689m 8:11  = 54.9711m 8:12  = 658.5128m
+ 9:10 = 653.5426m 9:11  = 653.4958m 9:12  = 53.0929m
+ 9:13 = 32.4248m

```

Opening plot unit= 16
file=cpdff1.tr0

```

** hspice file created for circuit cpdff: transient&power @ 25.0c
***** transient analysis      tnom= 25.000 temp= 25.000
*****
vmax      = 6.2537E-01 at= 3.4000E-08
from= 2.0000E-09 to= 4.0000E-08
vmin      = 5.0705E-02 at= 3.4475E-08
from= 2.0000E-09 to= 4.0000E-08
tphi      = 9.3060E-10 targ= 3.0370E-08 trig= 2.9440E-08
tplh      = 4.4528E-10 targ= 2.9885E-08 trig= 2.9440E-08
trise     = 4.1904E-10 targ= 3.0219E-08 trig= 2.9800E-08
tfall     = 1.9364E-10 targ= 3.0445E-08 trig= 3.0251E-08
tdelay    = 9.3260E-10 targ= 3.0371E-08 trig= 2.9439E-08
-
***** job concluded
total cpu time   68.01 seconds
job started at 8:43:4 2-feb93
job ended at 8:46:37 2-feb93

```

I am done with cpdff1.sp
Tue Feb 2 08:46:39 PST 1993

G. Listing File for DLATCH Transient Analysis @ 25.0C

```

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. ( 2000000 bytes)

```

```

***** h s p i c e 9007d    7:17:20 27-jan93 sun
** hspice file created for circuit dlatch: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
```

```

* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
***** * hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
***** * subcircuit dcfl d-latch using generic gates
*      d clk q /q power ground
.subckt dlatch 1 2 3 4 5 6
* ina inb output power ground subname
x0 1 2 8 5 6 d2nand
x1 1 7 5 6 dinv
x2 2 7 9 5 6 d2nand
x3 8 4 3 5 6 d2nand
x4 9 3 4 5 6 d2nand
.ends dlatch
*****
***** * hspice dcfl 2-input real nand subcircuit
*      ina, inb, output, power, ground
.subckt d2nand 1 2 3 4 5
* d g s b
j0 4 3 3 5 jfet16 l=1.2 w=6.0
j1 3 1 6 5 jfet04 l=1.2 w=192.0
j2 6 2 5 5 jfet04 l=1.2 w=192.0
.ends d2nand
*****
***** * hspice dcfl standard load subcircuit
*      input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card

```

```

*.temp 85.0

* signal inputs
* next line is for dc transfer analysis
*vin 999 0

* next three lines used to provide test signal inputs for transient analysis
va 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vb 101 0 pulse(0.063 0.63 8400ps 100ps 100ps 8200ps 16800ps)

* main circuit
* d clk q /q power ground
x3 101 100 104 105 1 0 dlatch $ element under test
x4 104 107 888 0 d2load $ test load
x5 105 108 888 0 d2load $ test load
* measurement parameters

* next two lines are used for dc transfer analysis
*.dc vin 0.00 0.63 0.001
*.probe dc out/in=v(104,0)

* next two lines are used for transient analysis
.probe din=v(101) clk=v(100) q=v(104) qnot=v(105)
.probe tran p(vds) p(vload) power

* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis
.meas tran vmax max v(104) from=2ns to=24ns
.meas tran vmin min v(104) from=2ns to=24ns
.meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=2ns
+ rise=1 targ v(104) val='(vmax-vmin)*.5' td=2ns fall=1
.meas tran tphh trig v(100) val='(vmax-vmin)*.5' td=2ns
+ rise=1 targ v(105) val='(vmax-vmin)*.5' td=2ns rise=1
.meas tran trise trig v(105) val='vmin+0.1*vmax' td=2ns
+ rise=1 targ v(105) val='0.9*vmax' rise=1
.meas tran tfall trig v(104) val='0.9*vmax' td=2ns
+ fall=1 targ v(104) val='vmin+0.1*vmax' fall=1
.meas tran tdelay trig v(100) val=.2835 td=20ns rise=1
+ targ v(104) val=.2835 td=20ns fall=1
.tran 50ps 24ns
.options scale=1e-06 brief=0 nopage measout post probe
.end

** hspice file created for circuit dlatch: transient&power @ 25.0c
***** circuit name directory
*****
circuit number to circuit name directory
number circuitname definition multiplier
 0 main circuit
 1 x3.          dlatch   1.00
 2 x4.          d2load   1.00

```

3 x5.	d2load	1.00
4 x3.x0.	d2nand	1.00
5 x3.x1.	dinv	1.00
6 x3.x2.	d2nand	1.00
7 x3.x3.	d2nand	1.00
8 x3.x4.	d2nand	1.00
9 x4.x0.	dinv	1.00
10 x4.x1.	dinv	1.00
11 x5.x0.	dinv	1.00
12 x5.x1.	dinv	1.00

Opening plot unit= 15
file=dlatch1.pa0

** hspice file created for circuit dlatch: transient&power @ 25.0c
***** operating point information tnom= 25.000 temp= 25.000

***** operating point status is voltage simulation time is 0.
node =voltage node =voltage node =voltage

+ 0:1	= 2.0000	0:100	= 63.0000m	0:101	= 63.0000m
+ 0:104	= 632.6195m	0:105	= 78.6713m	0:107	= 53.5871m
+ 0:108	= 1.9798	0:888	= 2.0000	1:7	= 622.5037m
+ 1:8	= 1.2482	1:9	= 678.4738m	2:5	= 53.5871m
+ 3:5	= 1.9798	4:6	= 73.6471m	6:6	= 8.6084m
+ 7:6	= 641.3001m	8:6	= 48.5086m		

Opening plot unit= 16
file=dlatch1.tr0

** hspice file created for circuit dlatch: transient&power @ 25.0c
***** transient analysis tnom= 25.000 temp= 25.000

vmax = 6.3262E-01 at= 2.0175E-08
from= 2.0000E-09 to= 2.4000E-08
vmin = 4.9117E-02 at= 1.2700E-08
from= 2.0000E-09 to= 2.4000E-08
tphl = 6.1047E-10 targ= 4.8508E-09 trig= 4.2403E-09
tplh = 2.2097E-10 targ= 4.4613E-09 trig= 4.2403E-09
trise = 5.3429E-10 targ= 4.8861E-09 trig= 4.3518E-09
tfall = 3.7997E-10 targ= 4.9966E-09 trig= 4.6166E-09
tdelay = 6.1734E-10 targ= 2.1656E-08 trig= 2.1039E-08

***** job concluded
total cpu time 19.75 seconds
job started at 7:17:20 27-jan93
job ended at 7:18: 2 27-jan93

I am done with dlatch1.sp
Wed Jan 27 07:18:04 PST 1993

H. Listing File for DELAY Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)

```
***** hspice 9007d 11:13:30-jan93 sun
** hspice file created for circuit delay: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
* subcircuit delay generates delayed clock pulse
*      input output power ground
.subckt delay 1 2 3 4
*   ina inb    out power ground subname
x0 1      9 3 4 bdinv
x1 9      6 3 4 bdinv
x2 1 6    2 3 4 bs2and
.ends delay
*****
* subcircuit sbfl 2-input nor
*      ina inb output power ground
.subckt bs2nor 1 2 3 4 5
* d g s
j0 8 1 5 0 jfet04 l=1.2 w=180.0
j1 8 2 5 0 jfet04 l=1.2 w=180.0
j2 4 8 8 0 jfet16 l=1.2 w=10.0
j3 4 8 3 0 jfet04 l=1.2 w=224.0
j4 3 2 5 0 jfet04 l=1.2 w=224.0
j5 3 1 5 0 jfet04 l=1.2 w=224.0
.ends bs2nor
*****
* subcircuit dcfl-sbfl 2- input and
*      ina inb output power ground
.subckt bs2and 1 2 3 4 5
*   ina inb out pwr gnd subname
x0 1      9 4 5 bdinv $dcfl gate
x1 2      6 4 5 bdinv $dcfl gate
x2 9      6 3 4 5 bs2nor $sbfl gate
```

```

.ends bs2and
*****
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt bdinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet20 l=3.0 w=40.0
j1 2 1 4 4 jfet04 l=1.2 w=240.0
.ends bdinv
*****
*****
* subcircuit sbfl inverter
*      input, output, power, ground
.subckt sinv 1 2 3 4
* d g s
j0 9 1 4 0 jfet04 l=1.2 w=48.0
j1 3 9 9 0 jfet16 l=1.2 w=3.0
j2 3 9 2 0 jfet04 l=1.2 w=48.0
j3 2 1 4 0 jfet04 l=1.2 w=48.0
.ends sinv
*****
*****
* hspice sbfl standard load subcircuit
*      input, output, power, ground
.subckt s10load 1 2 3 4
x0 1 5 3 4 sinv
x1 1 2 3 4 sinv
x2 1 6 3 4 sinv
x3 1 7 3 4 sinv
x4 1 8 3 4 sinv
x5 1 9 3 4 sinv
x6 1 10 3 4 sinv
x7 1 11 3 4 sinv
x8 1 12 3 4 sinv
x9 1 13 3 4 sinv
.ends s10load
*****
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
*
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card
*.temp 85.0

* signal inputs
* next line is for dc transfer analysis
*vin 999 0

```

* next line is used to provide the test signal input for transient analysis
v_a 0 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)

* main circuit

x3 100 104 1 0 delay \$ element under test
x4 104 107 888 0 s10load \$ test load

* measurement parameters

* next two lines are used for dc transfer analysis
.dc vin 0.00 0.63 0.001
.probe dc out/in=v(104,0)

* next two lines are used for transient analysis
.probe input=v(100) output=v(104)
.probe tran p(vds) p(vload) power

* next 8 lines will calculate vmax vmin trise ,fall and tdelay :transient analy
s

.meas tran vmax max v(104) from=2ns to=20ns
.meas tran vmin min v(104) from=2ns to=20ns
.meas tran tphi trig v(100) val='(vmax-vmin)*.5' td=2ns
+ rise=1 targ v(104) val='(vmax-vmin)*.5' td=2ns rise=1
.meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=2ns
+ fall=1 targ v(104) val='(vmax-vmin)*.5' td=2ns fall=1
.meas tran trise trig v(104) val='vmin+0.1*vmax' td=2ns
+ rise=1 targ v(104) val='0.9*vmax' rise=1
.meas tran tfall trig v(104) val='0.9*vmax' td=2ns
+ fall=2 targ v(104) val='vmin+0.1*vmax' fall=2
.meas tran tdelay trig v(100) val=.2835 td=2ns rise=1
+ targ v(104) val=.2835 rise=1
.tran 50ps 20ns
.options scale=1e-06 brief=0 nopage measout post probe
.end

** hspice file created for circuit del: y: transient&power @ 25.3c

***** circuit name directory

circuit number to circuit name directory

number circuitname definition multiplier

0 main circuit

1 x3.	delay	1.00
2 x4.	s10load	1.00
3 x3.x0.	bdiv	1.00
4 x3.x1.	bdiv	1.00
5 x3.x2.	bs2and	1.00
6 x4.x0.	sinv	1.00
7 x4.x1.	sinv	1.00
8 x4.x2.	sinv	1.00
9 x4.x3.	sinv	1.00
10 x4.x4.	sinv	1.00

11 x4.x5.	sinv	1.00
12 x4.x6.	sinv	1.00
13 x4.x7.	sinv	1.00
14 x4.x8.	sinv	1.00
15 x4.x9.	sinv	1.00
16 x3.x2.x0.	bdinv	1.00
17 x3.x2.x1.	bdinv	1.00
18 x3.x2.x2.	bs2nor	1.00

Opening plot unit= 15

file=delay1.pa0

```
** hspice file created for circuit delay: transient&power @ 25.0c
***** operating point information tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is 0.
node =voltage node =voltage node =voltage
```

+ 0:1	= 2.0000	0:100	= 63.0000m	0:104	= 7.0515m
+ 0:107	= 1.7620	0:888	= 2.0000	1:6	= 33.9777m
+ 1:9	= 636.1803m	2:5	= 1.7620	2:6	= 1.7620
+ 2:7	= 1.7620	2:8	= 1.7620	2:9	= 1.7620
+ 2:10	= 1.7620	2:11	= 1.7620	2:12	= 1.7620
+ 2:13	= 1.7620	5:6	= 613.1155m	5:9	= 612.9554m
+ 6:9	= 1.9945	7:9	= 1.9945	8:9	= 1.9945
+ 9:9	= 1.9945	10:9	= 1.9945	11:9	= 1.9945
+12:9	= 1.9945	13:9	= 1.9945	14:9	= 1.9945
+15:9	= 1.9945	18:8	= 26.8679m		—

Opening plot unit= 16

file=delay1.tr0

```
** hspice file created for circuit delay: transient&power @ 25.0c
***** transient analysis tnom= 25.000 temp= 25.000
*****
vmax      = 6.6232E-01 at= 1.6800E-08
from= 2.0000E-09 to= 2.0000E-08
vmin      = -1.8424E-02 at= 4.5000E-09
from= 2.0000E-09 to= 2.0000E-08
tphl      = 4.3145E-10 targ= 4.6804E-09 trig= 4.2489E-09
tplh      = 3.4595E-10 targ= 8.6970E-09 trig= 8.3511E-09
trise     = 2.5538E-10 targ= 4.8088E-09 trig= 4.5535E-09
tfall     = 3.0072E-10 targ= 1.7273E-08 trig= 1.6972E-08
tdelay    = 4.1530E-10 targ= 4.6542E-09 trig= 4.2389E-09
```

***** job concluded

total cpu time 30.94 seconds
job started at 11: 1:31 30-jan93
job ended at 11: 2:37 30-jan93

I am done with delay1.sp
Sat Jan 30 11:02:38 PST 1993

I. Listing File for LVL Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.l/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)

```
***** hspice 9007d 22:40:59 30-jan93 sun
** hspice file created for circuit lvl: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
***** subcircuit level-shifter to drive dfets
* use hspice diode models for backconnected mesfets
*      input output vds vss
.subckt lvl 1 2 3 4
* d g s b
x0 1 25 3 0 dinv
j1 3 25 6 4 jfet04 l=1.2 w=20.0
j2 7 6 7 4 dio16 l=1.2 w=4.0
j3 7 4 4 4 jfet20 l=3.0 w=3.0
j4 3 9 9 4 jfet16 l=1.2 w=3.0
j5 9 7 0 4 jfet16 l=1.2 w=10.0
j6 3 9 10 4 jfet16 l=1.2 w=20.0
j7 11 10 11 4 dio16 l=1.2 w=20.0
j8 2 11 2 4 dio16 l=1.2 w=20.0
j9 2 4 4 4 jfet16 l=1.2 w=12.0
j10 12 2 12 4 dio16 l=1.2 w=10.0
j11 13 12 13 4 dio16 l=1.2 w=10.0
j12 14 13 14 4 dio16 l=1.2 w=10.0
j13 4 14 4 4 dio16 l=1.2 w=10.0
.ends lvl
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
```

```

.ends dinv
*****
* hspice d mesfet load subcircuit
*      input, power, ground
.subckt dm10load 1 3 4
j0 3 1 4 4 jfet16 l=1.2 w= 10.0
j1 3 1 4 4 jfet16 l=1.2 w= 10.0
j2 3 1 4 4 jfet16 l=1.2 w= 10.0
j3 3 1 4 4 jfet16 l=1.2 w= 10.0
j4 3 1 4 4 jfet16 l=1.2 w= 10.0
j5 3 1 4 4 jfet16 l=1.2 w= 10.0
j6 3 1 4 4 jfet16 l=1.2 w= 10.0
j7 3 1 4 4 jfet16 l=1.2 w= 10.0
j8 3 1 4 4 jfet16 l=1.2 w= 10.0
j9 3 1 4 4 jfet16 l=1.2 w= 10.0
.ends dm10load
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vss 777 0 dc -2.5v $ test load negative power supply
vload 888 0 dc 2.0v $ test load positive power supply

* temperature card
*.temp 85.0

* signal inputs
* next line is for dc transfer analysis
*vin 999 0

* next line is used to provide the test signal input for transient analysis
va0 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)

* main circuit
x0 100 104 1 777 lvl      $ element under test
x1 104   888 0 dm10load  $ test load

* measurement parameters

* next two lines are used for dc transfer analysis
*.dc vin 0.00 0.63 0.001
*.probe dc out/in=v(104.0)

* next two lines are used for transient analysis
.probe input=v(100) output=v(104)
.probe tran p(vds) p(vss) p(vload) power

* next 8 lines will calculate vmax vmin trise tfall and tdelay :transient analy
s

```

```

.meas tran vimax max v(100) from=2ns to=20ns $ vmax input
.meas tran vimin min v(100) from=2ns to=20ns $ vmin input
.meas tran vmax max v(104) from=2ns to=20ns
.meas tran vmin min v(104) from=2ns to=20ns
.meas tran tphi trig v(100) val='(vmax-vimin)*.5' td=2ns
+ rise=1 targ v(104) val='(vmax+vmin)*.5' td=2ns rise=1
.meas tran tphl trig v(100) val='(vmax-vimin)*.5' td=2ns
+ fall=1 targ v(104) val='(vmax+vmin)*.5' td=2ns fall=1
.meas tran trise trig v(104) val='vmin+0.1*vmax' td=2ns
+ rise=1 targ v(104) val='0.9*vmax' rise=1
.meas tran tfall trig v(104) val='0.9*vmax' td=2ns
+ fall=2 targ v(104) val='vmin+0.1*vmax' fall=2
.meas tran tdelay trig v(100) val=.2835 td=2ns rise=1
+ targ v(104) val=-.6000 rise=1
.tran 50ps 20ns
.options scale=1e-06 brief=0 nopage measout post probe
.end
** hspice file created for circuit lvl: transient&power @ 25.0c
***** circuit name directory
*****
circuit number to circuit name directory
number circuitname definition multiplier
 0 main circuit
 1 x0.          lvl      1.00
 2 x1.          dm10load 1.00
 3 x0.x0.        dinv     1.00
Opening plot unit= 15
file=lv11.ps0

** hspice file created for circuit lvl: transient&power @ 25.0c
***** operating point information  tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is 0.
node =voltage node =voltage node =voltage

+0:1    = 2.0000 0:100   = 63.0000m 0:104   = -1.2402
+0:777  = -2.5000 0:888   = 2.0000 1:6     = 1.3537
+1:7    = 649.2362m 1:9    = 74.9851m 1:10   = 230.9228m
+1:11   = -504.6211m 1:12   = -1.5551 1:13   = -1.8701
+1:14   = -2.1850 1:25    = 1.9636

```

```

Opening plot unit= 16
file=lv11.tr0

** hspice file created for circuit lvl: transient&power @ 25.0c
***** transient analysis          tnom= 25.000 temp= 25.000
*****
vimax     = 6.3000E-01 at= 4.3000E-09

```

```

from= 2.0000E-09 to= 2.0000E-08
vimin = 6.3000E-02 at= 2.0000E-09
from= 2.0000E-09 to= 2.0000E-08
vmax = 1.0646E-01 at= 8.3500E-09
from= 2.0000E-09 to= 2.0000E-08
vmin = -1.2403E+00 at= 1.7199E-08
from= 2.0000E-09 to= 2.0000E-08
tphl = 2.9870E-10 targ= 4.5376E-09 trig= 4.2389E-09
tplh = 1.2030E-10 targ= 8.4814E-09 trig= 8.3611E-09
trise = 5.1389E-10 targ= 4.7920E-09 trig= 4.2781E-09
tfall = 2.4363E-10 targ= 1.7003E-08 trig= 1.6760E-08
tdelay = 2.9262E-10 targ= 4.5315E-09 trig= 4.2389E-09

```

```

***** job concluded
total cpu time 18.46 seconds
job started at 22:40:59 30-jan93
job ended at 22:41:40 30-jan93

```

I am done with lv11.sp
Sat Jan 30 22:41:41 PST 1993

J. Listing File for CLOCK Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)---

```

***** h s p i c e 9007d 19:53:59 2-feb93 sun
** hspice file created for circuit clock: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt bdinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet20 l=3.0 w=40.0
j1 2 1 4 4 jfet04 l=1.2 w=240.0
.ends bdinv
*****
* subcircuit sbfl 2-input nor
*      ina inb output power ground
.subckt bs2nor 1 2 3 4 5

```

```

* d g s
j0 8 1 5 0 jfet04 l=1.2 w=180.0
j1 8 2 5 0 jfet04 l=1.2 w=180.0
j2 4 8 8 0 jfet16 l=1.2 w=10.0
j3 4 8 3 0 jfet04 l=1.2 w=224.0
j4 3 2 5 0 jfet04 l=1.2 w=224.0
j5 3 1 5 0 jfet04 l=1.2 w=224.0
.ends bs2nor
*****
* subcircuit sbfl 2- input and
*      ina  inb  output power ground
.subckt bs2and 1 2 3 4 5
* ina inb out pwr gnd subname
x0 1 9 4 5 bdinv
x1 2 6 4 5 bdinv
x2 9 6 3 4 5 bs2nor
.ends bs2and
*****
***** subckt hspice sbfl large 2-input nor
*      ina  inb  output power ground
.subckt csnor 1 2 3 4 5
* d g s b
j0 8 1 5 0 jfet04 l=1.2 w=144.0
j1 8 2 5 0 jfet04 l=1.2 w=144.0
j2 4 8 8 0 jfet16 l=1.2 w= 9.0
j3 4 8 3 0 jfet04 l=1.2 w=144.0
j4 3 2 5 0 jfet04 l=1.2 w=144.0
j5 3 1 5 0 jfet04 l=1.2 w=144.0
.ends csnor
*****
* hspice sbfl extra-large driver-inverter subcircuit
*      input, output, power, ground
.subckt ssinv 1 2 3 4
* d g s b
j0 9 1 4 0 jfet04 l=1.2 w=768.0
j1 3 9 9 0 jfet16 l=1.2 w= 48.0
j2 3 9 2 0 jfet04 l=1.2 w=768.0
j3 2 1 4 0 jfet04 l=1.2 w=768.0
.ends ssinv
*****
* hspice sbfl large driver-inverter subcircuit
*      input, output, power, ground
.subckt csinv 1 2 3 4
* d g s b
j0 9 1 4 0 jfet04 l=1.2 w=256.0
j1 3 9 9 0 jfet16 l=1.2 w= 16.0
j2 3 9 2 0 jfet04 l=1.2 w=384.0
j3 2 1 4 0 jfet04 l=1.2 w=384.0
.ends csinv
*****

```

```

* subcircuit delay generates fee d
*      input output power ground
.subckt delay 1 2 3 4
* ina inb      out power ground subname
x0 1         9   3   4   bdinv
x1 9         6   3   4   bdinv
x2 1 6       2   3   4   bs2and
.ends delay
*****
* subcircuit for hspice two-phase sbfi clock
*      inclk ph1 ph2 ph2d ph11 ph2ld power1 power2 ground
.subckt clock 1 2 3 4 5 6 7 8 9
* ina inb out pwr gnd subname
x0 1 2 10 7 9 csnor
x1 10 11 7 9 ssinv
x2 11 3 7 9 ssinv
x3 12 3 13 7 9 csnor
x4 13 14 7 9 ssinv
x5 14 2 7 9 ssinv
x6 1 12 7 9 csinv
x7 3 4 7 9 delay
x8 2 5 7 8 lvl
x9 4 6 7 8 lvl
.ends clock
*****
*****  

* subcircuit level-shifter to drive dfets
* use hspice diode models for backconnected mesfets
*      input output vds vss
.subckt lvl 1 2 3 4
* d g s b
x0 1 25 3 0 dinv
j1 3 25 6 4 jfet04 l=1.2 w=20.0
j2 7 6 7 4 dio16 l=1.2 w=4.0
j3 7 4 4 4 jfet20 l=3.0 w=3.0
j4 3 9 9 4 jfet16 l=1.2 w=3.0
j5 9 7 0 4 jfet16 l=1.2 w=10.0
j6 3 9 10 4 jfet16 l=1.2 w=20.0
j7 11 10 11 4 dio16 l=1.2 w=20.0
j8 2 11 2 4 dio16 l=1.2 w=20.0
j9 2 4 4 4 jfet16 l=1.2 w=12.0
j10 12 2 12 4 dio16 l=1.2 w=10.0
j11 13 12 13 4 dio16 l=1.2 w=10.0
j12 14 13 14 4 dio16 l=1.2 w=10.0
j13 4 14 4 4 dio16 l=1.2 w=10.0
.ends lvl
*****
*****  

* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv 1 2 3 4

```

```

* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dmv
*****
* hspice d mesfet load subcircuit
*      input, power, ground
.subckt dm10load 1 3 4
j0 3 1 4 4 jfet16 l=1.2 w= 10.0
j1 3 1 4 4 jfet16 l=1.2 w= 10.0
j2 3 1 4 4 jfet16 l=1.2 w= 10.0
j3 3 1 4 4 jfet16 l=1.2 w= 10.0
j4 3 1 4 4 jfet16 l=1.2 w= 10.0
j5 3 1 4 4 jfet16 l=1.2 w= 10.0
j6 3 1 4 4 jfet16 l=1.2 w= 10.0
j7 3 1 4 4 jfet16 l=1.2 w= 10.0
j8 3 1 4 4 jfet16 l=1.2 w= 10.0
j9 3 1 4 4 jfet16 l=1.2 w= 10.0
.ends dm10load
*****
***** subcircuit sbfl inverter
*      input, output, power, ground
.subckt sinv 1 2 3 4
* d g s
j0 9 1 4 0 jfet04 l=1.2 w=48.0
j1 3 9 9 0 jfet16 l=1.2 w=3.0
j2 3 9 2 0 jfet04 l=1.2 w=48.0
j3 2 1 4 0 jfet04 l=1.2 w=48.0
.ends sinv
*****
* hspice sbfl standard load subcircuit
*      input, output, power, ground
.subckt s10load 1 2 3 4
x0 1 5 3 4 sinv
x1 1 2 3 4 sinv
x2 1 6 3 4 sinv
x3 1 7 3 4 sinv
x4 1 8 3 4 sinv
x5 1 9 3 4 sinv
x6 1 10 3 4 sinv
x7 1 11 3 4 sinv
x8 1 12 3 4 sinv
x9 1 13 3 4 sinv
.ends s10load
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies

```

```

vds 1 0 dc 2.0v $ element under test power supply
vss 777 0 dc -2.5v $ test load negative power supply
vload 888 0 dc 2.0v $ test load positive power supply

* temperature card
*.temp 85.0

* signal inputs
* next line is for dc transfer analysis
*vin 999 0

* next line is used to provide the test signal input for transient analysis
va0 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)

* main circuit
x0 100 104 105 106 107 108 1 777 0 clock $ element under test
x1 104 120      888    0 s10load $ test load
x2 105 121      888    0 s10load $ test load
x3 106 122      888    0 s10load $ test load
x4 107          888    0 dm10load $ test load
x5 108          888    0 dm10load $ test load

* measurement parameters

* next two lines are used for dc transfer analysis
*.dc vin 0.00 0.63 0.001
*.probe dc out/in=v(104,0)

* next two lines are used for transient analysis
.probe incclk=v(100) ph1=v(104) ph2=v(105) ph2d=v(106) ph1l=v(107)
+ ph2ld=v(108)
.probe tran p(vds) p(vss) p(vload) power
.measure tran avgpwr avg p(vds) from 0.0ns to 20ns
* next 8 lines will calculate vmax vmin trise tfall and tdelay :transient analy
s
.meas tran vimax max v(100) from=2ns to=20ns $ vmax input
.meas tran vimin min v(100) from=2ns to=20ns $ vmin input
.meas tran vmax max v(104) from=2ns to=20ns
.meas tran vmin min v(104) from=2ns to=20ns
* next line is adjustment necessary to facilitate measuring tfall. if
* vmin is used in tfall calc, then the tfall calculation fails as the is a larg
e
* all on to all off and this skews the targ parameter. notice that
* vmin2 is used only in the tfall calculation line.
.meas tran vmin2 find v(104) at=11ns
.meas tran tph1 trig v(100) val='(vimax-vimin)*.5' td=2ns
+ rise=1 targ v(104) val='(vmax+vmin)*.5' td=2ns rise=1
.meas tran tplh trig v(100) val='(vimax-vimin)*.5' td=2ns
+ fall=1 targ v(104) val='(vmax+vmin)*.5' td=2ns fall=1
.meas tran trise trig v(104) val='vmin+0.1*vmax' td=2ns
+ rise=1 targ v(104) val='0.9*vmax' rise=1

```

```

.meas tran tfall trig v(104) val='0.9*vmax' td=16ns
+ fall=1 targ v(104) val='vmin2+0.1*vmax' fall=1
.meas tran tdelay trig v(100) val=0.2835 td=2ns rise=1
+ targ v(104) val=0.2835 rise=1
.tran 550ps 20ns
.options scale=1e-06 brief=0 nopage measout post probe
.end
** hspice file created for circuit clock: transient&power @ 25.0c
***** circuit name directory
*****

```

circuit number to circuit name directory
 number circuitname definition multiplier

0 main circuit			
1 x0.	clock	1.00	
2 x1.	s10load	1.00	
3 x2.	s10load	1.00	
4 x3.	s10load	1.00	
5 x4.	dml0load	1.00	
6 x5.	dml0load	1.00	
7 x0.x0.	csnor	1.00	
8 x0.x1.	ssinv	1.00	
9 x0.x2.	ssinv	1.00	
10 x0.x3.	csnor	1.00	
11 x0.x4.	ssinv	1.00	
12 x0.x5.	ssinv	1.00	
13 x0.x6.	ssinv	1.00	
14 x0.x7.	delay	1.00	
15 x0.x8.	lvl	1.00	
16 x0.x9.	lvl	1.00	
17 x1.x0.	sinv	1.00	
18 x1.x1.	sinv	1.00	
19 x1.x2.	sinv	1.00	
20 x1.x3.	sinv	1.00	
21 x1.x4.	sinv	1.00	
22 x1.x5.	sinv	1.00	
23 x1.x6.	sinv	1.00	
24 x1.x7.	sinv	1.00	
25 x1.x8.	sinv	1.00	
26 x1.x9.	sinv	1.00	
27 x2.x0.	sinv	1.00	
28 x2.x1.	sinv	1.00	
29 x2.x2.	sinv	1.00	
30 x2.x3.	sinv	1.00	
31 x2.x4.	sinv	1.00	
32 x2.x5.	sinv	1.00	
33 x2.x6.	sinv	1.00	
34 x2.x7.	sinv	1.00	
35 x2.x8.	sinv	1.00	
36 x2.x9.	sinv	1.00	
37 x3.x0.	sinv	1.00	
38 x3.x1.	sinv	1.00	

39 x3.x2.	sinv	1.00
40 x3.x3.	sinv	1.00
41 x3.x4.	sinv	1.00
42 x3.x5.	sinv	1.00
43 x3.x6.	sinv	1.00
44 x3.x7.	sinv	1.00
45 x3.x8.	sinv	1.00
46 x3.x9.	sinv	1.00
47 x0.x7.x0.	bdinv	1.00
48 x0.x7.x1.	bdinv	1.00
49 x0.x7.x2.	bs2and	1.00
50 x0.x8.x0.	dinv	1.00
51 x0.x9.x0.	dinv	1.00
52 x0.x7.x2.x0.	bdinv	1.00
53 x0.x7.x2.x1.	bdinv	1.00
54 x0.x7.x2.x2.	bs2nor	1.00

Opening plot unit= 15

file=clock1.pa0

```
** hspice file created for circuit clock: transient&power @ 25.0c
***** operating point information  tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is 0.
node =voltage node =voltage node =voltage
```

```
+0:1 = 2.0000 0:100 = 63.0000m 0:104 = 31.9774m
+0:105 = 688.8112m 0:106 = 658.8150m 0:107 = -1.2402
+0:108 = 104.5431m 0:120 = 1.7422 0:121 = 30.1523m
+0:122 = 18.2371m 0:777 = -2.5000 0:888 = 2.0000
+1:10 = 633.6943m 1:11 = 11.3673m 1:12 = 724.8418m
+1:13 = 41.8449m 1:14 = 692.6584m 2:5 = 1.7422
+2:6 = 1.7422 2:7 = 1.7422 2:8 = 1.7422
+2:9 = 1.7422 2:10 = 1.7422 2:11 = 1.7422
+2:12 = 1.7422 2:13 = 1.7422 3:5 = 30.1523m
+3:6 = 30.1523m 3:7 = 30.1523m 3:8 = 30.1523m
+3:9 = 30.1523m 3:10 = 30.1523m 3:11 = 30.1523m
+3:12 = 30.1523m 3:13 = 30.1523m 4:5 = 18.2371m
+4:6 = 18.2371m 4:7 = 18.2371m 4:8 = 18.2371m
+4:9 = 18.2371m 4:10 = 18.2371m 4:11 = 18.2371m
+4:12 = 18.2371m 4:13 = 18.2371m 7:8 = 1.2978
+8:9 = 53.4430m 9:9 = 1.3520 10:8 = 51.8795m
+11:9 = 1.3555 12:9 = 56.8574m 13:9 = 1.3729
+14:6 = 636.3051m 14:9 = 44.0977m 15:6 = 1.3578
+15:7 = 652.5225m 15:9 = 74.9274m 15:10 = 230.8765m
+15:11 = -504.6670m 15:12 = -1.5552 15:13 = -1.8701
+15:14 = -2.1851 15:25 = 1.9694 16:6 = -379.7082m
+16:7 = -1.0722 16:9 = 1.9993 16:10 = 1.5989
+16:11 = 851.7082m 16:12 = -546.5927m 16:13 = -1.1977
+16:14 = -1.8489 16:25 = 52.0530m 17:9 = 1.9911
+18:9 = 1.9911 19:9 = 1.9911 20:9 = 1.9911
```

+21:9	= 1.9911	22:9	= 1.9911	23:9	= 1.9911
+24:9	= 1.9911	25:9	= 1.9911	26:9	= 1.9911
+27:9	= 55.9050m	28:9	= 55.9050m	29:9	= 55.9050m
+30:9	= 55.9050m	31:9	= 55.9050m	32:9	= 55.9050m
+33:9	= 55.9050m	34:9	= 55.9050m	35:9	= 55.9050m
+36:9	= 55.9050m	37:9	= 52.0576m	38:9	= 52.0576m
+39:9	= 52.0576m	40:9	= 52.0576m	41:9	= 52.0576m
+42:9	= 52.0576m	43:9	= 52.0576m	44:9	= 52.0576m
+45:9	= 52.0576m	46:9	= 52.0576m	49:6	= 33.9838m
+49:9	= 44.0977m	54:8	= 1.3110		

Opening plot unit= 16
file=clock1.tr0

```
** hspice file created for circuit clock: transient&power @ 25.0c
***** transient analysis      tmon= 25.000 temp= 25.000
*****
avgpwr    = -3.1516E-01 from= 0.0000E+00  to= 2.0000E-08
vimax     = 6.3000E-01 at= 4.3000E-09
           from= 2.0000E-09 to= 2.0000E-08
vimin     = 6.3000E-02 at= 2.0000E-09
           from= 2.0000E-09 to= 2.0000E-08
vmax      = 7.0077E-01 at= 8.6476E-09
           from= 2.0000E-09 to= 2.0000E-08
vmin      = -4.1470E-02 at= 4.8753E-09
           from= 2.0000E-09 to= 2.0000E-08
vmin2     = 3.1978E-02
tphl      = 7.2371E-10 targ= 4.9626E-09 trig= 4.2389E-09
tplh      = 3.8966E-10 targ= 8.7508E-09 trig= 8.3611E-09
trise     = 1.4221E-10 targ= 5.0374E-09 trig= 4.8952E-09
tfall     = 7.6519E-11 targ= 1.7178E-08 trig= 1.7102E-08
tdelay    = 7.1342E-10 targ= 4.9523E-09 trig= 4.2389E-09

***** job concluded
total cpu time   138.48 seconds
job started at 19:53:59 2-feb93
job ended at 20: 1:17 2-feb93
```

I am done with clock1.sp
Tue Feb 2 20:01:18 PST 1993

K. Listing File for DECODER Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
 lic: license granted by the license server for hspice
 lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
 reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
 setting user memory from environment var to 250000 words. (2000000 bytes)

```

***** h s p i c e 9007d      20: 9:10 2-feb93 sun
** hspice file created for circuit decoder: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
***** subcircuit sbfl 3-input or
*     ina    inb   inc  output power ground
.subckt s3or  1  2  3  4  5  6
*     ina    inb   inc  out  pwr  gnd  subname
x0 1 2 3 7 5 6 s3nor
x1 7        4 5 6 sinv
.ends s3or
*****
***** subcircuit sbfl 4-input and
*     ina    inb   inc  ind  output power ground
.subckt ss4and 1 2 3 4 5 6 7
*     ina    inb   inc  ind  out  pwr  gnd  subname
x0 1          9 6 7 sinv
x1 2          10 6 7 sinv
x2 3          11 6 7 sinv
x3 4          12 6 7 sinv
x4 9 10 11 12 5 6 7 s4nor
.ends ss4and
*****
***** subcircuit sbfl 4-input nor
*     ina    inb   inc  ind  output power ground
.subckt s4nor 1 2 3 4 5 6 7
*     d g s
j0 8 1 7 0 jfet04 l=1.2 w=48.0
j1 8 2 7 0 jfet04 l=1.2 w=48.0
j2 8 3 7 0 jfet04 l=1.2 w=48.0
j3 8 4 7 0 jfet04 l=1.2 w=48.0
j4 6 8 8 0 jfet16 l=1.2 w=3.0
j5 6 8 5 0 jfet04 l=1.2 w=48.0
j6 5 1 7 0 jfet04 l=1.2 w=48.0
j7 5 2 7 0 jfet04 l=1.2 w=48.0
j8 5 3 7 0 jfet04 l=1.2 w=48.0
j9 5 4 7 0 jfet04 l=1.2 w=48.0
.ends s4nor
*****
***** subcircuit sbfl 3-input nor
*     ina    inb   inc  output power ground

```

```

.subckt s3nor 1 2 3 4 5 6
* d g s
j0 8 1 6 0 jfet04 l=1.2 w=48.0
j1 8 2 6 0 jfet04 l=1.2 w=48.0
j2 8 3 6 0 jfet04 l=1.2 w=48.0
j3 5 8 8 0 jfet16 l=1.2 w=3.0
j4 5 8 4 0 jfet04 l=1.2 w=48.0
j5 4 1 6 0 jfet04 l=1.2 w=48.0
j6 4 2 6 0 jfet04 l=1.2 w=48.0
j7 4 3 6 0 jfet04 l=1.2 w=48.0
.ends s3nor
*****
*****  

* subcircuit sbfl inverter
* input, output, power, ground
.subckt sinv 1 2 3 4
* d g s
j0 9 1 4 0 jfet04 l=1.2 w=48.0
j1 3 9 9 0 jfet16 l=1.2 w=3.0
j2 3 9 2 0 jfet16 l=1.2 w=48.0
j3 2 1 4 0 jfet04 l=1.2 w=48.0
.ends sinv
*****
*****  

* hspice dcfl inverter subcircuit
* input, output, power, ground
.subckt dinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
*****  

* hspice sbfl standard load subcircuit
* input, output, power, ground
.subckt s4load 1 2 3 4
x0 1 5 3 4 sinv
x1 1 2 3 4 sinv
x2 1 6 3 4 sinv
x3 1 7 3 4 sinv
.ends s4load
*****
*****  

* subcircuit non-latched sbfl/dcfl combination decoder
**** a0 a1 a2 w r re o0 o1 o2 o3 o4 o5 o6 o7 enbl pwr grnd
.subckt decoder 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
* ina inb inc ind output power ground subname
x1 1 20 16 17 dinv
x2 2 18 16 17 dinv
x3 3 19 16 17 dinv
x4 4 5 6 15 16 17 s3or

```

```

x5 20 18 19 15    7   16 17 ss4and
x6 1 18 19 15     8   16 17 ss4and
x7 20 2 19 15     9   16 17 ss4and
x8 1 2 19 15      10  16 17 ss4and
x9 20 18 3 15     11  16 17 ss4and
x10 1 18 3 15     12  16 17 ss4and
x11 20 2 3 15     13  16 17 ss4and
x12 1 2 3 15      14  16 17 ss4and
.ends decoder
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card
*.temp 85.0

* signal inputs
* next line is for dc transfer analysis
*vin 999 0

* next three lines used to provide test signal inputs for transient analysis
va 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vb 101 0 pulse(0.063 0.63 8400ps 100ps 100ps 8200ps 16800ps)
vc 102 0 pulse(0.063 0.63 16800ps 100ps 100ps 16600ps 33600ps)
vr 103 0 0.63v
vw 104 0 0.63v
vre 105 0 0.63v

* main circuit
* a0 a1 a2 w r re o0 o1 o2 o3 o4 o5 o6 o7 enbl pwr grnd
x0 100 101 102 104 103 105 110 111 112 113 114 115 116 117 120 1 0 decoder
x1 110          210 888 0 s4load
x2 111          211 888 0 s4load
x3 112          212 888 0 s4load
x4 113          213 888 0 s4load
x5 114          214 888 0 s4load
x6 115          215 888 0 s4load
x7 116          216 888 0 s4load
x8 117          217 888 0 s4load

* measurement parameters

* next two lines are used for dc transfer analysis
*.dc vin 0.00 0.63 0.001
*.probe dc out/in=v(104.0)

* next two lines are used for transient analysis

```

```

.probe ina=v(100) inb=v(101) inc=v(102) r=v(103) w=v(104) re=v(105)
+ o0=v(110) o1=v(111) o2=v(112) o3=v(113) o4=v(114) o5=v(115) o6=v(116)
+ o7=v(117) enbl=v(120)
.probe tran p(vds) p(vload) power
.measure tran avgpwr avg p(vds)

* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis
.meas tran vmax max v(100) from=2ns to=50ns
.meas tran vmin min v(100) from=2ns to=50ns
.meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=35ns
+ rise=1 targ v(110) val='(vmax-vmin)*.5' td=35ns fall=1
.meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=32ns
+ fall=1 targ v(110) val='(vmax-vmin)*.5' td=32ns rise=1
.meas tran trise trig v(110) val='vmin+0.1*vmax' td=32ns
+ rise=1 targ v(110) val=0.9*vmax' rise=1
.meas tran tfall trig v(110) val='0.9*vmax' td=32ns
+ fall=1 targ v(110) val='vmin+0.1*vmax' td=32ns fall=1
.meas tran tdelay trig v(100) val=.2835 td=32ns fall=1
+ targ v(110) val=.2835 td=32ns rise=1
.tran 500ps 50ns
.options scale=1e-06 brief=0 nopage measout post probe
.end

** hspice file created for circuit decoder: transient&power @ 25.0c
***** circuit name directory
*****
```

circuit number to circuit name directory
 number circuitname definition multiplier

0 main circuit			
1 x0.	decoder	1.00	
2 x1.	s4load	1.00	
3 x2.	s4load	1.00	
4 x3.	s4load	1.00	
5 x4.	s4load	1.00	
6 x5.	s4load	1.00	
7 x6.	s4load	1.00	
8 x7.	s4load	1.00	
9 x8.	s4load	1.00	
10 x0.x1.	dinv	1.00	
11 x0.x2.	dinv	1.00	
12 x0.x3.	dinv	1.00	
13 x0.x4.	s3or	1.00	
14 x0.x5.	ss4and	1.00	
15 x0.x6.	ss4and	1.00	
16 x0.x7.	ss4and	1.00	
17 x0.x8.	ss4and	1.00	
18 x0.x9.	ss4and	1.00	
19 x0.x10.	ss4and	1.00	
20 x0.x11.	ss4and	1.00	
21 x0.x12.	ss4and	1.00	
22 x1.x0.	sinv	1.00	
23 x1.x1.	sinv	1.00	

24 x1.x2.	sinv	1.00
25 x1.x3.	sinv	1.00
26 x2.x0.	sinv	1.00
27 x2.x1.	sinv	1.00
28 x2.x2.	sinv	1.00
29 x2.x3.	sinv	1.00
30 x3.x0.	sinv	1.00
31 x3.x1.	sinv	1.00
32 x3.x2.	sinv	1.00
33 x3.x3.	sinv	1.00
34 x4.x0.	sinv	1.00
35 x4.x1.	sinv	1.00
36 x4.x2.	sinv	1.00
37 x4.x3.	sinv	1.00
38 x5.x0.	sinv	1.00
39 x5.x1.	sinv	1.00
40 x5.x2.	sinv	1.00
41 x5.x3.	sinv	1.00
42 x6.x0.	sinv	1.00
43 x6.x1.	sinv	1.00
44 x6.x2.	sinv	1.00
45 x6.x3.	sinv	1.00
46 x7.x0.	sinv	1.00
47 x7.x1.	sinv	1.00
48 x7.x2.	sinv	1.00
49 x7.x3.	sinv	1.00
50 x8.x0.	sinv	1.00
51 x8.x1.	sinv	1.00
52 x8.x2.	sinv	1.00
53 x8.x3.	sinv	1.00
54 x0.x4.x0.	s3nor	1.00
55 x0.x4.x1.	sinv	1.00
56 x0.x5.x0.	sinv	1.00
57 x0.x5.x1.	sinv	1.00
58 x0.x5.x2.	sinv	1.00
59 x0.x5.x3.	sinv	1.00
60 x0.x5.x4.	s4nor	1.00
61 x0.x6.x0.	sinv	1.00
62 x0.x6.x1.	sinv	1.00
63 x0.x6.x2.	sinv	1.00
64 x0.x6.x3.	sinv	1.00
65 x0.x6.x4.	s4nor	1.00
66 x0.x7.x0.	sinv	1.00
67 x0.x7.x1.	sinv	1.00
68 x0.x7.x2.	sinv	1.00
69 x0.x7.x3.	sinv	1.00
70 x0.x7.x4.	s4nor	1.00
71 x0.x8.x0.	sinv	1.00
72 x0.x8.x1.	sinv	1.00
73 x0.x8.x2.	sinv	1.00
74 x0.x8.x3.	sinv	1.00

75 x0.x8.x4.	s4nor	1.00
76 x0.x9.x0.	sinv	1.00
77 x0.x9.x1.	sinv	1.00
78 x0.x9.x2.	sinv	1.00
79 x0.x9.x3.	sinv	1.00
80 x0.x9.x4.	s4nor	1.00
81 x0.x10.x0.	sinv	1.00
82 x0.x10.x1.	sinv	1.00
83 x0.x10.x2.	sinv	1.00
84 x0.x10.x3.	sinv	1.00
85 x0.x10.x4.	s4nor	1.00
86 x0.x11.x0.	sinv	1.00
87 x0.x11.x1.	sinv	1.00
88 x0.x11.x2.	sinv	1.00
89 x0.x11.x3.	sinv	1.00
90 x0.x11.x4.	s4nor	1.00
91 x0.x12.x0.	sinv	1.00
92 x0.x12.x1.	sinv	1.00
93 x0.x12.x2.	sinv	1.00
94 x0.x12.x3.	sinv	1.00
95 x0.x12.x4.	s4nor	1.00

Opening plot unit= 15

file=decoder1.pa0

```
** hspice file created for circuit decoder: transient&power @ 25.0c
***** operating point information  tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is  0.
      node =voltage    node =voltage    node =voltage
```

```
+0:1   = 2.0000 0:100   = 63.0000m 0:101   = 63.0000m
+0:102  = 63.0000m 0:103   = 630.0000m 0:104   = 630.0000m
+0:105  = 630.0000m 0:110   = 643.3119m 0:111   = 31.9148m
+0:112  = 31.9148m 0:113   = 30.9112m 0:114   = 31.9148m
+0:115  = 30.9112m 0:116   = 30.9112m 0:117   = 30.5639m
+0:120  = 620.7250m 0:210   = 13.6773m 0:211   = 1.7422
+0:212  = 1.7422 0:213   = 1.7430 0:214   = 1.7422
+0:215  = 1.7430 0:216   = 1.7430 0:217   = 1.7433
+0:888  = 2.0000 1:18   = 606.6802m 1:19   = 606.6802m
+1:20   = 606.6802m 2:5   = 13.6773m 2:6   = 13.6773m
+2:7   = 13.6773m 3:5   = 1.7422 3:6   = 1.7422
+3:7   = 1.7422 4:5   = 1.7422 4:6   = 1.7422
+4:7   = 1.7422 5:5   = 1.7430 5:6   = 1.7430
+5:7   = 1.7430 6:5   = 1.7422 6:6   = 1.7422
+6:7   = 1.7422 7:5   = 1.7430 7:6   = 1.7430
+7:7   = 1.7430 8:5   = 1.7430 8:6   = 1.7430
+8:7   = 1.7430 9:5   = 1.7433 9:6   = 1.7433
+9:7   = 1.7433 13:7   = 10.0800m 14:9   = 6.7572m
+14:10  = 6.7572m 14:11  = 6.7572m 14:12  = 8.8318m
+15:9   = 692.5577m 15:10  = 6.7572m 15:11  = 6.7572m
```

+15:12	= 8.8318m 16:9	= 6.7572m 16:10	= 692.5577m
+16:11	= 6.7572m 16:12	= 8.8318m 17:9	= 690.7612m
+17:10	= 690.7612m 17:11	= 6.7572m 17:12	= 8.8318m
+18:9	= 6.7572m 18:10	= 6.7572m 18:11	= 692.5577m
+18:12	= 8.8318m 19:9	= 690.7612m 19:10	= 6.7572m
+19:11	= 690.7612m 19:12	= 8.8318m 20:9	= 6.7572m
+20:10	= 690.7612m 20:11	= 690.7612m 20:12	= 8.8318m
+21:9	= 690.1019m 21:10	= 690.1019m 21:11	= 690.1019m
+21:12	= 8.8318m 22:9	= 52.4532m 23:9	= 52.4532m
+24:9	= 52.4532m 25:9	= 52.4532m 26:9	= 1.9911
+27:9	= 1.9911 28:9	= 1.9911 29:9	= 1.9911
+30:9	= 1.9911 31:9	= 1.9911 32:9	= 1.9911
+33:9	= 1.9911 34:9	= 1.9913 35:9	= 1.9913
+36:9	= 1.9913 37:9	= 1.9913 38:9	= 1.9911
+39:9	= 1.9911 40:9	= 1.9911 41:9	= 1.9911
+42:9	= 1.9913 43:9	= 1.9913 44:9	= 1.9913
+45:9	= 1.9913 46:9	= 1.9913 47:9	= 1.9913
+48:9	= 1.9913 49:9	= 1.9913 50:9	= 1.9914
+51:9	= 1.9914 52:9	= 1.9914 53:9	= 1.9914
+54:8	= 22.8197m 55:9	= 1.2859 56:9	= 58.9751m
+57:9	= 58.9751m 58:9	= 58.9751m 59:9	= 55.6117m
+60:8	= 1.3073 61:9	= 1.3552 62:9	= 58.9751m
+63:9	= 58.9751m 64:9	= 55.6117m 65:8	= 56.8042m
+66:9	= 58.9751m 67:9	= 1.3552 68:9	= 58.9751m
+69:9	= 55.6117m 70:8	= 56.8042m 71:9	= 1.3534
+72:9	= 1.3534 73:9	= 58.9751m 74:9	= 55.6117m
+75:8	= 42.5420m 76:9	= 58.9751m 77:9	= 58.9751m
+78:9	= 1.3552 79:9	= 55.6117m 80:8	= 56.8042m
+81:9	= 1.3534 82:9	= 58.9751m 83:9	= 1.3534
+84:9	= 55.6117m 85:8	= 42.5420m 86:9	= 58.9751m
+87:9	= 1.3534 88:9	= 1.3534 89:9	= 55.6117m
+90:8	= 42.5420m 91:9	= 1.3528 92:9	= 1.3528
+93:9	= 1.3528 94:9	= 55.6117m 95:8	= 38.1558m

Opening plot unit= 16
 file=decoder1.tr0

```
** hspice file created for circuit decoder: transient&power @ 25.0c
***** transient analysis          tnom= 25.000 temp= 25.000
*****
avgpwr      = -1.2518E-01 from= 0.0000E+00 to= 5.0000E-08
vmax        = 6.3000E-01 at= 4.3000E-09
              from= 2.0000E-09 to= 5.0000E-08
vmin        = 6.3000E-02 at= 2.0000E-09
              from= 2.0000E-09 to= 5.0000E-08
tphi        = 3.2624E-10 targ= 3.8165E-08 trig= 3.7839E-08
tplh        = 5.5513E-10 targ= 3.4116E-09 trig= 3.3561E-08
trise       = 2.8580E-10 targ= 3.4318E-08 trig= 3.4032E-08
tfall       = 2.0350E-10 targ= 3.8268E-08 trig= 3.8064E-08
```

tdelay = 5.5513E-10 targ= 3.4116E-08 trig= 3.3561E-08

***** job concluded
total cpu time 306.61 seconds
job started at 20: 9:10 2-feb93
job ended at 20:25:19 2-feb93

I am done with decoder1.sp
Tue Feb 2 20:25:20 PST 1993

L. Listing File for COUNTER Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)

```
***** h s p i c e 9007d 11:42: 2 3-feb93 sun
** hspice file created for circuit counter: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
* hspice dcfl 2-input nor subcircuit
*      ina, inb, output, power, ground
.subckt d2nor 1 2 3 4 5
* d g s b
j0 4 3 3 5 jfet16 l=1.2 w=6.0
j1 3 1 5 5 jfet04 l=1.2 w=96.0
j2 3 2 5 5 jfet04 l=1.2 w=96.0
.ends d2nor
*****
* hspice dcfl 2-input demorgan and subcircuit
*      ina, inb, output, power, ground
.subckt dd2and 1 2 3 4 5
x0 1 10 4 5 dinv
x1 2 11 4 5 dinv
x2 10 11 3 4 5 d2nor
.ends dd2and
*****
* subcircuit dcfl 2-input or
*      ina inb output power ground
.subckt dd2or 1 2 3 4 5
```

```

* ina inb out pwr gnd subname
x0 1 2 6 4 5 d2nor
x1 6 3 4 5 dinv
.ends dd2or
*****
*****
* hspice dcfl 3-input nor subcircuit
*      ina, inb, inc, output, power, ground
.subckt d3nor 1 2 3 4 5 6
* d g s b
j0 5 4 4 6 jfet16 l=1.2 w=6.0
j1 4 1 6 6 jfet04 l=1.2 w=96.0
j2 4 2 6 6 jfet04 l=1.2 w=96.0
j3 4 3 6 6 jfet04 l=1.2 w=96.0
.ends d3nor
*****
*
* hspice dcfl 3-input demorgan and subcircuit
*      ina, inb, inc, output, power, ground
.subckt dd3and 1 2 3 4 5 6
x0 1 10 5 6 dinv
x1 2 11 5 6 dinv
x2 3 12 5 6 dinv
x3 10 11 12 4 5 6 d3nor
.ends dd3and
*****
*****
* subcircuit dcfl 3-input or
*      ina inb inc output power ground
.subckt dd3or 1 2 3 4 5 6
* ina inb inc out pwr gnd subname
x0 1 2 3 7 5 6 d3nor
x1 7 4 5 6 dinv
.ends dd3or
*****
*****
* hspice dcfl 4-input nor subcircuit
*      ina, inb, inc, ind, output, power, ground
.subckt d4nor 1 2 3 4 5 6 7
* d g s b
j0 6 5 5 7 jfet16 l=1.2 w=6.0
j1 5 1 7 7 jfet04 l=1.2 w=96.0
j2 5 2 7 7 jfet04 l=1.2 w=96.0
j3 5 3 7 7 jfet04 l=1.2 w=96.0
j4 5 4 7 7 jfet04 l=1.2 w=96.0
.ends d4nor
*****
*****
* subcircuit dcfl 4-input or
*      ina inb inc ind output power ground
.subckt dd4or 1 2 3 4 5 6 7

```

```

* ina inb inc ind out pwr gnd subname
x0 1 2 3 4 8 6 7 d4nor
x1 8      5 6 7 dinv
.ends dd4or
*****
*****  

* hspice dcfl 4-input demorgan and subcircuit
*      ina, inb, inc, ind, output, power, ground
.subckt dd4and 1 2 3 4 5 6 7
x0 1      10 6 7 dinv
x1 2      11 6 7 dinv
x2 3      12 6 7 dinv
x3 4      13 6 7 dinv
x4 10 11 12 13 5 6 7 d4nor
.ends dd4and
*****
*****  

* subcircuit hspice dcfl clear d flip flop
* wakerly pg 363 - 31july 1992
***      d clk clr q /q power ground
.subckt cpdff 1 2 3 4 5 6 7
x0 12 10    9 6 7 dd2nand
x1 9 3 2    10 6 7 dd3nand
x2 10 2 12   11 6 7 dd3nand
x3 11 3 1    12 6 7 dd3nand
x4 10 5      4 6 7 dd2nand
x5 4 3 11   5 6 7 dd3nand
.ends cpdff
*****
*****  

* hspice dcfl 2-input demorgan nand subcircuit
*      ina, inb, output, power, ground
.subckt dd2nand 1 2 3 4 5
x0 1 10 4 5 dinv
x1 2 11 4 5 dinv
x2 10 11 12 4 5 d2nor
x3 12 3 4 5 dinv
.ends dd2nand
*****
*****  

* hspice dcfl 3-input demorgan nand subcircuit
*      ina, inb, inc, output, power, ground
.subckt dd3nand 1 2 3 4 5 6
x0 1 10 5 6 dinv
x1 2 11 5 6 dinv
x2 3 12 5 6 dinv
x3 10 11 12 13 5 6 d3nor
x4 13 4 5 6 dinv
.ends dd3nand
*****
*****
```

```

* subcircuit sbfl inverter
*      input, output, power, ground
.subckt sinv 1 2 3 4
* d g s
j0 9 1 4 0 jfet04 l=1.2 w=48.0
j1 3 9 9 0 jfet16 l=1.2 w=3.0
j2 3 9 2 0 jfet04 l=1.2 w=48.0
j3 2 1 4 0 jfet04 l=1.2 w=48.0
.ends sinv
*****
*****  

* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
*****  

* hspice dcfl standard load subcircuit
*      input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
*****  

* hspice sbfl standard load subcircuit
*      input, output, power, ground
.subckt s4load 1 2 3 4
x0 1 5 3 4 sinv
x1 1 2 3 4 sinv
x2 1 6 3 4 sinv
x3 1 7 3 4 sinv
.ends s4load
*****
*****  

* subcircuit dcfl counter using clear/preset d fps - cpdiff
***      enable clk q0 q1 q2 /q0/q1 /q2 power ground
.subckt counter 1 2 3 4 5 6 7 8 9 10
*** ina inb inc ind d clk q /q out power ground subname
x0 1           11 9 10 dinv
x1 3 11         12 9 10 dd2and
x2 1 6          13 9 10 dd2and
x3 12 13        20 9 10 dd2or
x4 4 11         14 9 10 dd2and
x5 4 6          15 9 10 dd2and
x6 3 7 1         16 9 10 dd3and
x7 14 15 16      21 9 10 dd3or
x8 5 7          17 9 10 dd2and

```

```

x9 5 6      18 9 10 dd2and
x10 1 3 4 8   19 9 10 dd4and
x11 11 5     23 9 10 dd2and
x12 17 18 19 23  22 9 10 dd4or
x13 20 2 1    3 6   9 10 cpdff
x14 21 2 1    4 7   9 10 cpdff
x15 22 2 1    5 8   9 10 cpdff
.ends counter
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card
*.temp 85.0

* signal inputs
* next line is for dc transfer analysis
*vin 999 0

* next three lines used to provide test signal inputs for transient analysis
vcik 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
venble 101 0 pulse(0.063 0.63 10000ps 100ps 100ps 88400ps 98200ps)

* main circuit
* enble clk q0 q1 q2 /q0/q1/q2 power ground subname
x0 101 100 110 111 112 120 121 122 1 0 counter
x1 110      210 888 0 d2load
x2 111      211 888 0 d2load
x3 112      212 888 0 d2load
x4 120      220 888 0 d2load
x5 121      221 888 0 d2load
x6 122      222 888 0 d2load

* measurement parameters

* next two lines are used for transient analysis
.probe clk=v(100) enable=v(101) q0=v(110) q1=v(111) q2=v(112)
+
/q0=v(120) /q1=v(121) /q2=v(122)
.probe tran p(vds) p(vload) power
.measure tran avgpwr avg p(vds) from 0.0ns to 88ns

* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis
.meas tran vmax max v(110) from=2ns to=88ns
.meas tran vmin min v(110) from=2ns to=88ns
.meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=20ns
+ rise=1 targ v(110) val='(vmax-vmin)*.5' td=20ns fall=1

```

```

.meas tran tphi trig v(100) val='(vmax-vmin)*.5' td=10ns
+ rise=1 targ v(110) val='(vmax-vmin)*.5' td=10ns rise=1
.meas tran trise trig v(110) val='vmin+0.1*vmax' td=10ns
+ rise=1 targ v(110) val='0.9*vmax' rise=1
.meas tran tfall trig v(110) val='0.9*vmax' td=20ns
+ fall=1 targ v(110) val='vmin+0.1*vmax' td=20ns fall=1
.meas tran tdelay trig v(100) val=.2835 td=20ns rise=1
+ targ v(110) val=.2835 td=20ns fall=1
.tran 2500ps 88ns
.options scale=1e-06 brief=0 nopage measout post probe
.end
** hspice file created for circuit counter: transient&power @ 25.0c
***** circuit name directory
*****
circuit number to circuit name directory
number circuitname definition multiplier
0 main circuit
 1 x0.          counter  1.00
 2 x1.          d2load   1.00
 3 x2.          d2load   1.00
 4 x3.          d2load   1.00
 5 x4.          d2load   1.00
 6 x5.          d2load   1.00
 7 x6.          d2load   1.00
 8 x0.x0.        dinv    1.00
 9 x0.x1.        dd2and   1.00
10 x0.x2.       dd2and   1.00
11 x0.x3.       dd2or    1.00
12 x0.x4.       dd2and   1.00
13 x0.x5.       dd2and   1.00
14 x0.x6.       dd3and   1.00
15 x0.x7.       dd3or    1.00
16 x0.x8.       dd2and   1.00
17 x0.x9.       dd2and   1.00
18 x0.x10.      dd4and   1.00
19 x0.x11.      dd2and   1.00
20 x0.x12.      dd4or    1.00
21 x0.x13.      cpdff    1.00
22 x0.x14.      cpdff    1.00
23 x0.x15.      cpdff    1.00
24 x1.x0.        dinv    1.00
25 x1.x1.        dinv    1.00
26 x2.x0.        dinv    1.00
27 x2.x1.        dinv    1.00
28 x3.x0.        dinv    1.00
29 x3.x1.        dinv    1.00
30 x4.x0.        dinv    1.00
31 x4.x1.        dinv    1.00
32 x5.x0.        dinv    1.00
33 x5.x1.        dinv    1.00
34 x6.x0.        dinv    1.00

```

35 x6.x1.	dinv	1.00
36 x0.x1.x0.	dinv	1.00
37 x0.x1.x1.	dinv	1.00
38 x0.x1.x2.	d2nor	1.00
39 x0.x2.x0.	dinv	1.00
40 x0.x2.x1.	dinv	1.00
41 x0.x2.x2.	d2nor	1.00
42 x0.x3.x0.	d2nor	1.00
43 x0.x3.x1.	dinv	1.00
44 x0.x4.x0.	dinv	1.00
45 x0.x4.x1.	dinv	1.00
46 x0.x4.x2.	d2nor	1.00
47 x0.x5.x0.	dinv	1.00
48 x0.x5.x1.	dinv	1.00
49 x0.x5.x2.	d2nor	1.00
50 x0.x6.x0.	dinv	1.00
51 x0.x6.x1.	dinv	1.00
52 x0.x6.x2.	dinv	1.00
53 x0.x6.x3.	d3nor	1.00
54 x0.x7.x0.	d3nor	1.00
55 x0.x7.x1.	dinv	1.00
56 x0.x8.x0.	dinv	1.00
57 x0.x8.x1.	dinv	1.00
58 x0.x8.x2.	d2nor	1.00
59 x0.x9.x0.	dinv	1.00
60 x0.x9.x1.	dinv	1.00
61 x0.x9.x2.	d2nor	1.00
62 x0.x10.x0.	dinv	1.00
63 x0.x10.x1.	dinv	1.00
64 x0.x10.x2.	dinv	1.00
65 x0.x10.x3.	dinv	1.00
66 x0.x10.x4.	d4nor	1.00
67 x0.x11.x0.	dinv	1.00
68 x0.x11.x1.	dinv	1.00
69 x0.x11.x2.	d2nor	1.00
70 x0.x12.x0.	d4nor	1.00
71 x0.x12.x1.	dinv	1.00
72 x0.x13.x0.	dd2nand	1.00
73 x0.x13.x1.	dd3nand	1.00
74 x0.x13.x2.	dd3nand	1.00
75 x0.x13.x3.	dd3nand	1.00
76 x0.x13.x4.	dd2nand	1.00
77 x0.x13.x5.	dd3nand	1.00
78 x0.x14.x0.	dd2nand	1.00
79 x0.x14.x1.	dd3nand	1.00
80 x0.x14.x2.	dd3nand	1.00
81 x0.x14.x3.	dd3nand	1.00
82 x0.x14.x4.	dd2nand	1.00
83 x0.x14.x5.	dd3nand	1.00
84 x0.x15.x0.	dd2nand	1.00
85 x0.x15.x1.	dd3nand	1.00

86 x0.x15.x2.	dd3nand	1.00
87 x0.x15.x3.	dd3nand	1.00
88 x0.x15.x4.	dd2nand	1.00
89 x0.x15.x5.	dd3nand	1.00
90 x0.x13.x0.x0.	dinv	1.00
91 x0.x13.x0.x1.	dinv	1.00
92 x0.x13.x0.x2.	d2nor	1.00
93 x0.x13.x0.x3.	dinv	1.00
94 x0.x13.x1.x0.	dinv	1.00
95 x0.x13.x1.x1.	dinv	1.00
96 x0.x13.x1.x2.	dinv	1.00
97 x0.x13.x1.x3.	d3nor	1.00
98 x0.x13.x1.x4.	dinv	1.00
99 x0.x13.x2.x0.	dinv	1.00
100 x0.x13.x2.x1.	dinv	1.00
101 x0.x13.x2.x2.	dinv	1.00
102 x0.x13.x2.x3.	d3nor	1.00
103 x0.x13.x2.x4.	dinv	1.00
104 x0.x13.x3.x0.	dinv	1.00
105 x0.x13.x3.x1.	dinv	1.00
106 x0.x13.x3.x2.	dinv	1.00
107 x0.x13.x3.x3.	d3nor	1.00
108 x0.x13.x3.x4.	dinv	1.00
109 x0.x13.x4.x0.	dinv	1.00
110 x0.x13.x4.x1.	dinv	1.00
111 x0.x13.x4.x2.	d2nor	1.00
112 x0.x13.x4.x3.	dinv	1.00
113 x0.x13.x5.x0.	dinv	1.00
114 x0.x13.x5.x1.	dinv	1.00
115 x0.x13.x5.x2.	dinv	1.00
116 x0.x13.x5.x3.	d3nor	1.00
117 x0.x13.x5.x4.	dinv	1.00
118 x0.x14.x0.x0.	dinv	1.00
119 x0.x14.x0.x1.	dinv	1.00
120 x0.x14.x0.x2.	d2nor	1.00
121 x0.x14.x0.x3.	dinv	1.00
122 x0.x14.x1.x0.	dinv	1.00
123 x0.x14.x1.x1.	dinv	1.00
124 x0.x14.x1.x2.	dinv	1.00
125 x0.x14.x1.x3.	d3nor	1.00
126 x0.x14.x1.x4.	dinv	1.00
127 x0.x14.x2.x0.	dinv	1.00
128 x0.x14.x2.x1.	dinv	1.00
129 x0.x14.x2.x2.	dinv	1.00
130 x0.x14.x2.x3.	d3nor	1.00
131 x0.x14.x2.x4.	dinv	1.00
132 x0.x14.x3.x0.	dinv	1.00
133 x0.x14.x3.x1.	dinv	1.00
134 x0.x14.x3.x2.	dinv	1.00
135 x0.x14.x3.x3.	d3nor	1.00
136 x0.x14.x3.x4.	dinv	1.00

137 x0.x14.x4.x0.	dinv	1.00
138 x0.x14.x4.x1.	dinv	1.00
139 x0.x14.x4.x2.	d2nor	1.00
140 x0.x14.x4.x3.	dinv	1.00
141 x0.x14.x5.x0.	dinv	1.00
142 x0.x14.x5.x1.	dinv	1.00
143 x0.x14.x5.x2.	dinv	1.00
144 x0.x14.x5.x3.	d3nor	1.00
145 x0.x14.x5.x4.	dinv	1.00
146 x0.x15.x0.x0.	dinv	1.00
147 x0.x15.x0.x1.	dinv	1.00
148 x0.x15.x0.x2.	d2nor	1.00
149 x0.x15.x0.x3.	dinv	1.00
150 x0.x15.x1.x0.	dinv	1.00
151 x0.x15.x1.x1.	dinv	1.00
152 x0.x15.x1.x2.	dinv	1.00
153 x0.x15.x1.x3.	d3nor	1.00
154 x0.x15.x1.x4.	dinv	1.00
155 x0.x15.x2.x0.	dinv	1.00
156 x0.x15.x2.x1.	dinv	1.00
157 x0.x15.x2.x2.	dinv	1.00
158 x0.x15.x2.x3.	d3nor	1.00
159 x0.x15.x2.x4.	dinv	1.00
160 x0.x15.x3.x0.	dinv	1.00
161 x0.x15.x3.x1.	dinv	1.00
162 x0.x15.x3.x2.	dinv	1.00
163 x0.x15.x3.x3.	d3nor	1.00
164 x0.x15.x3.x4.	dinv	1.00
165 x0.x15.x4.x0.	dinv	1.00
166 x0.x15.x4.x1.	dinv	1.00
167 x0.x15.x4.x2.	d2nor	1.00
168 x0.x15.x4.x3.	dinv	1.00
169 x0.x15.x5.x0.	dinv	1.00
170 x0.x15.x5.x1.	dinv	1.00
171 x0.x15.x5.x2.	dinv	1.00
172 x0.x15.x5.x3.	d3nor	1.00
173 x0.x15.x5.x4.	dinv	1.00

Opening plot unit= 15

file=counter1.pa0

** hspice file created for circuit counter: transient&power @ 25.0c

***** operating point information tnom= 25.000 temp= 25.000

***** operating point status is voltage simulation time is 0.

node =voltage node =voltage node =voltage

+ 0:1 = 2.0000	0:100 = 63.0000m	0:101 = 63.0000m
+ 0:110 = 52.0499m	0:111 = 52.0501m	0:112 = 52.0502m
+ 0:120 = 602.9491m	0:121 = 608.4583m	0:122 = 615.2330m
+ 0:210 = 1.9872	0:211 = 1.9872	0:212 = 1.9872

+ 0:220 = 60.0405m 0:221 = 58.4926m 0:222 = 56.8042m
 + 0:888 = 2.0000 1:11 = 623.9374m 1:12 = 52.0087m
 + 1:13 = 52.0005m 1:14 = 52.0087m 1:15 = 52.0017m
 + 1:16 = 32.4223m 1:17 = 52.0039m 1:18 = 52.0017m
 + 1:19 = 26.2272m 1:20 = 52.0509m 1:21 = 52.0488m
 + 1:22 = 52.0458m 1:23 = 52.0087m 2:5 = 1.9872
 + 3:5 = 1.9872 4:5 = 1.9872 5:5 = 60.0405m
 + 6:5 = 58.4926m 7:5 = 56.8042m 9:10 = 658.6792m
 + 9:11 = 54.9887m 10:10 = 658.6298m 10:11 = 60.0405m
 + 11:6 = 658.5363m 12:10 = 658.6792m 12:11 = 54.9887m
 + 13:10 = 658.6777m 13:11 = 60.0405m 14:10 = 653.5418m
 + 14:11 = 58.4926m 14:12 = 653.4950m 15:7 = 658.4424m
 + 16:10 = 658.6782m 16:11 = 58.4926m 17:10 = 658.6777m
 + 17:11 = 60.0405m 18:10 = 651.4782m 18:11 = 651.5247m
 + 18:12 = 651.5247m 18:13 = 56.8042m 19:10 = 54.9887m
 + 19:11 = 658.6792m 20:8 = 658.3021m 21:9 = 52.0506m
 + 21:10 = 624.0441m 21:11 = 636.5449m 21:12 = 636.5992m
 + 22:9 = 52.0506m 22:10 = 624.0441m 22:11 = 636.5449m
 + 22:12 = 636.5992m 23:9 = 52.0506m 23:10 = 624.0441m
 + 23:11 = 636.5449m 23:12 = 636.5992m 72:10 = 53.0867m
 + 72:11 = 54.9689m 72:12 = 658.5204m 73:10 = 651.5268m
 + 73:11 = 651.4803m 73:12 = 651.4803m 73:13 = 26.2332m
 + 74:10 = 54.9689m 74:11 = 658.6219m 74:12 = 53.0867m
 + 74:13 = 51.9641m 75:10 = 53.0929m 75:11 = 653.4958m
 + 75:12 = 653.5426m 75:13 = 32.4248m 76:10 = 54.9689m
 + 76:11 = 60.0405m 76:12 = 658.4906m 77:10 = 653.5426m
 + 77:11 = 653.4958m 77:12 = 53.0929m 77:13 = 32.4248m
 + 78:10 = 53.0867m 78:11 = 54.9689m 78:12 = 658.5204m
 + 79:10 = 651.5268m 79:11 = 651.4803m 79:12 = 651.4803m
 + 79:13 = 26.2332m 80:10 = 54.9689m 80:11 = 658.6219m
 + 80:12 = 53.0867m 80:13 = 51.9641m 81:10 = 53.0929m
 + 81:11 = 653.4958m 81:12 = 653.5426m 81:13 = 32.4248m
 + 82:10 = 54.9689m 82:11 = 58.4926m 82:12 = 658.4976m
 + 83:10 = 653.5426m 83:11 = 653.4958m 83:12 = 53.0929m
 + 83:13 = 32.4248m 84:10 = 53.0867m 84:11 = 54.9689m
 + 84:12 = 658.5204m 85:10 = 651.5268m 85:11 = 651.4803m
 + 85:12 = 651.4803m 85:13 = 26.2332m 86:10 = 54.9689m
 + 86:11 = 658.6219m 86:12 = 53.0867m 86:13 = 51.9641m
 + 87:10 = 53.0929m 87:11 = 653.4958m 87:12 = 653.5426m
 + 87:13 = 32.4248m 88:10 = 54.9689m 88:11 = 56.8042m
 + 88:12 = 658.5051m 89:10 = 653.5426m 89:11 = 653.4958m
 + 89:12 = 53.0929m 89:13 = 32.4248m

Opening plot unit= 16
 file=counter1.tr0

** hspice file created for circuit counter: transient&power @ 25.0c
 ***** transient analysis tnom= 25.000 temp= 25.000

```

avgpwr      = -2.7612E-01 from= 0.0000E+00 to= 8.8000E-08
vmax        = 6.0395E-01 at= 7.2275E-08
              from= 2.0000E-09 to= 8.8000E-08
vmin        = 4.7781E-02 at= 3.9181E-08
              from= 2.0000E-09 to= 8.8000E-08
tphl        = 1.1171E-09 targ= 2.2155E-08 trig= 2.1038E-08
tplh        = 5.0023E-10 targ= 1.3138E-08 trig= 1.2638E-08
trise       = 6.5525E-10 targ= 1.3671E-08 trig= 1.3016E-08
tfall       = 2.5412E-10 targ= 2.2265E-08 trig= 2.2011E-08
tdelay      = 1.1138E-09 targ= 2.2153E-08 trig= 2.1039E-08

```

```

***** job concluded
total cpu time   569.23 seconds
job started at 11:42:2 3-feb93
job ended at 12:11:26 3-feb93

```

I am done with counter1.sp
Wed Feb 3 12:11:27 PST 1993

M. Listing File for DREFRESH Transient Analysis @ 25.0C

```

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading insta'l configuration file: /tools3/cad/meta/h9007/meta.cfg
reading design configuration file: drefresh1.cfg
setting user memory from environment var to 250000 words. ( 2000000 bytes)

***** h s p i c e 9007d    20:28:46 3-feb93 sun
** hspice file created for circuit drefresh: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
* hspice dcfl standard load subcircuit
*     input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
* subcircuit sbfl 2-input nor
*     ina inb output power ground
.subckt s2nor 1 2 3 4 5
* d g s

```

```

j0 8 1 5 0 jfet04 l=1.2 w=48.0
j1 8 2 5 0 jfet04 l=1.2 w=48.0
j2 4 8 8 0 jfet16 l=1.2 w=3.0
j3 4 8 3 0 jfet04 l=1.2 w=48.0
j4 3 2 5 0 jfet04 l=1.2 w=48.0
j5 3 1 5 0 jfet04 l=1.2 w=48.0
.ends s2nor
*****
*****
* subcircuit sbfl 2-input nand
*      ina  inb  output power ground
.subckt ss2nand 1 2 3 4 5
*  ina inb out pwr gnd subname
x0 1 9 4 5 sinv
x1 2 6 4 5 sinv
x2 9 6 7 4 5 s2nor
x3 7 3 4 5 sinv
.ends ss2nand
*****
*****
* subcircuit dcfl sd-latch using generic gates
*      d  clk q /q power ground
.subckt sdlatch 1 2 3 4 5 6
** sbfl d latch **
*  ina inb output power ground subname
x0 1 2 8 5 6 d2nand
x1 1 7 5 6 dinv
x2 2 7 9 5 6 d2nand
x3 8 4 3 5 6 ss2nand
x4 9 3 4 5 6 ss2nand
.ends sdlatch
*****
*****
* subcircuit dcfl d-latch using generic gates
*      d  clk q /q power ground
.subckt dlatch 1 2 3 4 5 6
*  ina inb output power ground subname
x0 1 2 8 5 6 d2nand
x1 1 7 5 6 dinv
x2 2 7 9 5 6 d2nand
x3 8 4 3 5 6 d2nand
x4 9 3 4 5 6 d2nand
.ends dlatch
*****
*****
* hspice dcfl 2-input real nand subcircuit
*      ina, inb, output, power, ground
.subckt d2nand 1 2 3 4 5
*  d g s b
j0 4 3 3 5 jfet16 l=1.2 w=6.0
j1 3 1 6 5 jfet04 l=1.2 w=192.0

```

```

j2 6 2 5 5 jfet04 l=1.2 w=192.0
.ends d2nand
*****
*****
* subcircuit sbfl 4-input nor
*      ina inb inc ind output power ground
.subckt s4nor 1 2 3 4 5 6 7
* d g s
j0 8 1 7 0 jfet04 l=1.2 w=48.0
j1 8 2 7 0 jfet04 l=1.2 w=48.0
j2 8 3 7 0 jfet04 l=1.2 w=48.0
j3 8 4 7 0 jfet04 l=1.2 w=48.0
j4 6 8 8 0 jfet16 l=1.2 w=3.0
j5 6 8 5 0 jfet04 l=1.2 w=48.0
j6 5 1 7 0 jfet04 l=1.2 w=48.0
j7 5 2 7 0 jfet04 l=1.2 w=48.0
j8 5 3 7 0 jfet04 l=1.2 w=48.0
j9 5 4 7 0 jfet04 l=1.2 w=48.0
.ends s4nor
*****
*****
* hspice dcfl 2-input nor subcircuit
*      ina, inb, output, power, ground
.subckt d2nor 1 2 3 4 5
* d g s b
j0 4 3 3 5 jfet16 l=1.2 w=6.0
j1 3 1 5 5 jfet04 l=1.2 w=96.0
j2 3 2 5 5 jfet04 l=1.2 w=96.0
.ends d2nor
*****
*****
* hspice dcfl 2-input demorgan and subcircuit
*      ina, inb, output, power, ground
.subckt dd2and 1 2 3 4 5
x0 1 10 4 5 dinv
x1 2 11 4 5 dinv
x2 10 11 3 4 5 d2nor
.ends dd2and
*****
*****
* subcircuit dcfl 2-input or
*      ina inb output power ground
.subckt dd2or 1 2 3 4 5
* ina inb out pwr gnd subname
x0 1 2 6 4 5 d2nor
x1 6 3 4 5 dinv
.ends dd2or
*****
*****
* hspice dcfl 3-input nor subcircuit
*      ina, inb, inc, output, power, ground

```

```

.subckt d3nor 1 2 3 4 5 6
* d g s b
j0 5 4 4 6 jfet16 l=1.2 w=6.0
j1 4 1 6 6 jfet04 l=1.2 w=96.0
j2 4 2 6 6 jfet04 l=1.2 w=96.0
j3 4 3 6 6 jfet04 l=1.2 w=96.0
.ends d3nor
*****
* hspice dcfl 3-input demorgan and subcircuit
* ina, inb, inc, output, power, ground
.subckt dd3and 1 2 3 4 5 6
x0 1 10 5 6 dinv
x1 2 11 5 6 dinv
x2 3 12 5 6 dinv
x3 10 11 12 4 5 6 d3nor
.ends dd3and
*****
*****  

* subcircuit dcfl 3-input or
* ina inb inc output power ground
.subckt dd3or 1 2 3 4 5 6
* ina inb inc out pwr gnd subname
x0 1 2 3 7 5 6 d3nor
x1 7 4 5 6 dinv
.ends dd3or
*****
*****  

* hspice dcfl 4-input nor subcircuit
* ina, inb, inc, ind, output, power, ground
.subckt d4nor 1 2 3 4 5 6 7
* d g s b
j0 6 5 5 7 jfet16 l=1.2 w=6.0
j1 5 1 7 7 jfet04 l=1.2 w=96.0
j2 5 2 7 7 jfet04 l=1.2 w=96.0
j3 5 3 7 7 jfet04 l=1.2 w=96.0
j4 5 4 7 7 jfet04 l=1.2 w=96.0
.ends d4nor
*****
*****  

* subcircuit dcfl 4-input or
* ina inb inc ind output power ground
.subckt dd4or 1 2 3 4 5 6 7
* ina inb inc ind out pwr gnd subname
x0 1 2 3 4 8 6 7 d4nor
x1 8 5 6 7 dinv
.ends dd4or
*****
*****  

* hspice dcfl 4-input demorgan and subcircuit
* ina, inb, inc, ind, output, power, ground

```

```

.subckt dd4and 1 2 3 4 5 6 7
x0 1      10 6 7 dinv
x1 2      11 6 7 dinv
x2 3      12 6 7 dinv
x3 4      13 6 7 dinv
x4 10 11 12 13 5 6 7 d4nor
.ends dd4and
*****
***** subcircuit hspice dcfl clear d flip flop
* wakerly pg 363 - 31july 1992
***      d clk clr q /q power ground
.subckt cpdff 1 2 3 4 5 6 7
x0 12 10    9 6 7 dd2nand
x1 9 3 2    10 6 7 dd3nand
x2 10 2 12   11 6 7 dd3nand
x3 11 3 1    12 6 7 dd3nand
x4 10 5      4 6 7 dd2nand
x5 4 3 11   5 6 7 dd3nand
.ends cpdff
*****
***** hspice dcfl 2-input demorgan nand subcircuit
*      ina, inb, output, power, ground
.subckt dd2nand 1 2 3 4 5
x0 1 10 4 5 dinv
x1 2 11 4 5 dinv
x2 10 11 12 4 5 d2nor
x3 12 3 4 5 dinv
.ends dd2nand
*****
***** hspice dcfl 3-input demorgan nand subcircuit
*      ina, inb, inc, output, power, ground
.subckt dd3nand 1 2 3 4 5 6
x0 1 10 5 6 dinv
x1 2 11 5 6 dinv
x2 3 12 5 6 dinv
x3 10 11 12 13 5 6 d3nor
x4 13 4 5 6 dinv
.ends dd3nand
*****
***** subcircuit dcfl counter using clear/preset d fps - cpdff
***      enble clk q0 q1 q2 /q0 /q1 /q2 power ground
.subckt counter 1 2 3 4 5 6 7 8 9 10
*** ina inb inc ind d clk q /q out power ground subname
x0 1          11 9 10 dinv
x1 3 11       12 9 10 dd2and
x2 1 6        13 9 10 dd2and
x3 12 13      20 9 10 dd2or

```

```

x4 4 11      14 9 10 dd2and
x5 4 6       15 9 10 dd2and
x6 3 7 1     16 9 10 dd3and
x7 14 15 16   21 9 10 dd3or
x8 5 7       17 9 10 dd2and
x9 5 6       18 9 10 dd2and
x10 1 3 4 8    19 9 10 dd4and
x11 11 5     23 9 10 dd2and
x12 17 18 19 23  22 9 10 dd4or
x13 20 2 1     3 6   9 10 cpdff
x14 21 2 1     4 7   9 10 cpdff
x15 22 2 1     5 8   9 10 cpdff
.ends counter
*****
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt bdinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet20 l=3.0 w=40.0
j1 2 1 4 4 jfet04 l=1.2 w=240.0
.ends bdinv
*****
*
* subcircuit sbfl 2-input nor
*      ina  inb output power ground
.subckt bs2nor 1 2 3 4 5
* d g s
j0 8 1 5 0 jfet04 l=1.2 w=180.0
j1 8 2 5 0 jfet04 l=1.2 w=180.0
j2 4 8 8 0 jfet16 l=1.2 w=10.0
j3 4 8 3 0 jfet04 l=1.2 w=224.0
j4 3 2 5 0 jfet04 l=1.2 w=224.0
j5 3 1 5 0 jfet04 l=1.2 w=224.0
.ends bs2nor
*****
*
* subcircuit sbfl 2- input and
*      ina  inb output power ground
.subckt bs2and 1 2 3 4 5
* ina inb out pwr gnd subname
x0 1   9 4 5 bdinv
x1 2   6 4 5 bdinv
x2 9   6 3 4 5 bs2nor
.ends bs2and
*****
*****
* subckt hspice sbfl large 2-input nor
*      ina  inb output power ground
.subckt csnor 1 2 3 4 5
* d g s b
j0 8 1 5 0 jfet04 l=1.2 w=144.0
j1 8 2 5 0 jfet04 l=1.2 w=144.0

```

```

j2 4 8 8 0 jfet16 l=1.2 w= 9.0
j3 4 8 3 0 jfet04 l=1.2 w=144.0
j4 3 2 5 0 jfet04 l=1.2 w=144.0
j5 3 1 5 0 jfet04 l=1.2 w=144.0
.ends csnor
*****
* hspice sbfl extra-large driver-inverter subcircuit
*      input, output, power, ground
.subckt ssinv  1   2   3   4
* d g s b
j0 9 1 4 0 jfet04 l=1.2 w=768.0
j1 3 9 9 0 jfet16 l=1.2 w= 48.0
j2 3 9 2 0 jfet04 l=1.2 w=768.0
j3 2 1 4 0 jfet04 l=1.2 w=768.0
.ends ssinv
*****
* hspice sbfl large driver-inverter subcircuit
*      input, output, power, ground
.subckt csinv  1   2   3   4
* d g s b
j0 9 1 4 0 jfet04 l=1.2 w=256.0
j1 3 9 9 0 jfet16 l=1.2 w= 16.0
j2 3 9 2 0 jfet04 l=1.2 w=384.0
j3 2 1 4 0 jfet04 l=1.2 w=384.0
.ends csinv
*****
* subcircuit sbfl 4-input nand
*      ina inb inc ind output power ground
.subckt ss4nand 1  2  3  4  5  6  7
* ina inb inc ind out pwr gnd subname
x0 1      9 6 7 sinv
x1 2      10 6 7 sinv
x2 3      11 6 7 sinv
x3 4      12 6 7 sinv
x4 9 10 11 12 8 6 7 s4nor
x5 8      5 6 7 sinv
.ends ss4nand
*****
*****
* subcircuit delay generates fee d
*      input output power ground
.subckt delay 1  2  3  4
* ina inb      out power ground subname
x0 1      9 3 4 bdinv
x1 9      6 3 4 bdinv
x2 1 6    2 3 4 bs2and
.ends delay
*****
* subcircuit for hspice two-phase sbfl clock
*      inclk phi1 ph2 ph2d ph11 ph2ld power1 power2 ground
.subckt clock 1  2  3  4  5  6  7  8  9

```

```

* ina inb out pwr gnd subname
x0 1 2 10 7 9 csnor
x1 10 11 7 9 ssinv
x2 11 3 7 9 ssinv
x3 12 3 13 7 9 csnor
x4 13 14 7 9 ssinv
x5 14 2 7 9 ssinv
x6 1 12 7 9 csinv
x7 3 4 7 9 delay
x8 2 5 7 8 lvl
x9 4 6 7 8 lvl
.ends clock
*****
*****  

* subcircuit level-shifter to drive dfets
* use hspice diode models for backconnected mesfets
*      input output vds vss
.subckt lvl 1 2 3 4
* d g s b
x0 1 25 3 0 dinv
j1 3 25 6 4 jfet04 l=1.2 w=20.0
j2 7 6 7 4 dio16 l=1.2 w=4.0
j3 7 4 4 4 jfet20 l=3.0 w=3.0
j4 3 9 9 4 jfet16 l=1.2 w=3.0
j5 9 7 0 4 jfet16 l=1.2 w=10.0
j6 3 9 10 4 jfet16 l=1.2 w=20.0
j7 11 10 11 4 dio16 l=1.2 w=20.0
j8 2 11 2 4 dio16 l=1.2 w=20.0
j9 2 4 4 4 jfet16 l=1.2 w=12.0
j10 12 2 12 4 dio16 l=1.2 w=10.0
j11 13 12 13 4 dio16 l=1.2 w=10.0
j12 14 13 14 4 dio16 l=1.2 w=10.0
j13 4 14 4 4 dio16 l=1.2 w=10.0
.ends lvl
*****
*****  

* subcircuit dcfl with sbfl outputs d flip-flop
***      d clk q /q power ground
.subckt sdff 1 2 3 4 5 6
** sbfl d flip flop
* ina inb d clk q /q out power ground subname
x0 1 9 7 8 5 6 dlatch
x1 2 9 5 6 dinv
x2 9 10 5 6 dinv
x3 7 10 3 4 5 6 sdlatch
.ends sdff
*****
*****  

* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv 1 2 3 4

```

```

* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
* hspice d mesfet load subcircuit
*      input, power, ground
.subckt dm10load 1 3 4
j0 3 1 4 4 jfet16 l=1.2 w= 10.0
j1 3 1 4 4 jfet16 l=1.2 w= 10.0
j2 3 1 4 4 jfet16 l=1.2 w= 10.0
j3 3 1 4 4 jfet16 l=1.2 w= 10.0
j4 3 1 4 4 jfet16 l=1.2 w= 10.0
j5 3 1 4 4 jfet16 l=1.2 w= 10.0
j6 3 1 4 4 jfet16 l=1.2 w= 10.0
j7 3 1 4 4 jfet16 l=1.2 w= 10.0
j8 3 1 4 4 jfet16 l=1.2 w= 10.0
j9 3 1 4 4 jfet16 l=1.2 w= 10.0
.ends dm10load
*****
*****
```

```

* subcircuit sbfl inverter
*      input, output, power, ground
.subckt sinv 1 2 3 4
* d g s
j0 9 1 4 0 jfet04 l=1.2 w=48.0
j1 3 9 9 0 jfet16 l=1.2 w=3.0
j2 3 9 2 0 jfet04 l=1.2 w=48.0
j3 2 1 4 0 jfet04 l=1.2 w=48.0
.ends sinv
*****
*****
```

```

* hspice sbfl standard load subcircuit
*      input, output, power, ground
.subckt s10load 1 2 3 4
x0 1 5 3 4 sinv
x1 1 2 3 4 sinv
x2 1 6 3 4 sinv
x3 1 7 3 4 sinv
x4 1 8 3 4 sinv
x5 1 9 3 4 sinv
x6 1 10 3 4 sinv
x7 1 11 3 4 sinv
x8 1 12 3 4 sinv
x9 1 13 3 4 sinv
.ends s10load
*****
*****
```

```

* subcircuit dcfl/sbfl combination refresh circuit
*      refresh ph 1 clock a0 a1 a2 ao0 ao1 ao2 mrefresh power ground
.subckt drefresh 1 2 3 4 5 6 7 8 9 10 11

```

```

*** ina inb inc ind d clk q /q out power ground subname
x0 15 28 29 30      31 10 11 ss4nand
x1 31 2      9 33 10 11 sdff
x2 31 2 25 26 27 28 29 30 10 11 counter
x3 3      12 10 11 dinv
x4 4      13 10 11 dinv
x5 5      14 10 11 dinv
x6 1      15 10 11 dinv
x7 3 33      16 10 11 dd2and
x8 3 25      17 10 11 dd2and
x9 12 25 9      18 10 11 dd3and
x10 4 33      19 10 11 dd2and
x11 4 26      20 10 11 dd2and
x12 13 26 9      21 10 11 dd3and
x13 5 33      22 10 11 dd2and
x14 5 27      23 10 11 dd2and
x15 14 27 9      24 10 11 dd3and
x16 16 17 18      6 10 11 dd3or
x17 19 20 21      7 10 11 dd3or
x18 22 23 24      8 10 11 dd3or
.ic v(25)=0.0 v(26)=0.0 v(27)=0.0 v(31)=0.0 v(9)=0.0
+ v(28)=0.63 v(29)=0.63 v(30)=0.63 v(33)=0.63
.ends drefresh
*****

```

* ***** hspice version *****
 * include vitesse hgaas3 models and parameters for hspice.

* power supplies
 vds 1 0 dc 2.0v \$ element under test power supply
 vss 777 0 dc -2.5v \$ test load negative power supply
 vload 888 0 dc 2.0v \$ test load positive power supply

* temperature card
 *.temp 85.0

* signal inputs

* next line is used to provide the test signal input for transient analysis
 va0 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
 va1 101 0 pulse(0.063 0.63 8400ps 100ps 100ps 8200ps 16800ps)
 va2 102 0 pulse(0.063 0.63 16800ps 100ps 100ps 16600ps 33600ps)
 vref 200 0 pulse(0.63 0.063 33600ps 100ps 100ps 63400ps 87200ps)

* main circuit

*inclk ph1 ph2 ph2d ph11 ph21d power1 power2 ground
 x0 100 104 105 106 107 108 888 777 0 clock
 * ref ph1 a0 a1 a2 a0 a1 a02 mrefresh pwr gnd
 x1 200 104 100 101 102 120 121 122 130 1 0 drefresh
 * standard dcfl loads on the outputs of the circuit under test
 x2 120 220 888 0 d2load

x3 121	221	888 0 d2load
x4 122	222	888 0 d2load
x5 130	230	888 0 d2load

* measurement parameters

* next lines are used for transient analysis

```
.probe ph1=v(104) ref=v(200) a0=v(100) a1=v(101) a2=v(102)
+ ao0=v(120) ao1=v(121) ao2=v(122) mref=v(130)
```

```
.probe tran p(vds) p(vss) power
```

```
.measure tran avgpwr avg p(vds) from 0.0ns to 80ns
```

* next 8 lines will calculate vmax vmin trise tfall and tdelay :transient analy

s

```
.meas tran vimax max v(100) from=2ns to=20ns $ vmax input
```

```
.meas tran vimin min v(100) from=2ns to=20ns $ vmin input
```

```
.meas tran vmax max v(120) from=2ns to=20ns
```

```
.meas tran vmin min v(120) from=2ns to=20ns
```

* next line is adjustment necessary to facilitate measuring tfall. if

* vmin is used in tfall calc, then the tfall calculation fails as the is a larg

e

* all on to all off and this skews the targ parameter. notice that

* vmin2 is used only in the tfall calculation line.

```
*.meas tran vmin2 find v(104) at=11ns
```

```
.meas tran tphl trig v(104) val='(vmax-vimin)*.5' td=28ns
```

```
+ rise=1 targ v(120) val='(vmax+vmin)*.5' td=30ns fall=1
```

```
.meas tran tplh trig v(104) val='(vmax-vimin)*.5' td=20ns
```

```
+ rise=1 targ v(120) val='(vmax+vmin)*.5' td=20ns rise=1
```

```
.meas tran trise trig v(120) val='vmin+0.1*vmax' td=20ns
```

```
+ rise=1 targ v(120) val='0.9*vmax' rise=1
```

```
.meas tran tfall trig v(120) val='0.9*vmax' td=30ns
```

```
+ fall=1 targ v(120) val='vmin+0.1*vmax' td=30ns fall=1
```

```
.meas tran tdelay trig v(104) val=0.2835 td=20ns rise=1
```

```
+ targ v(120) val=0.2835 rise=1
```

```
.tran 1000ps 80ns
```

```
.options scale=1e-06 brief=0 nopage measout post probe
```

```
.end
```

** hspice file created for circuit drefresh: transient&power @ 25.0c

***** circuit name directory

circuit number to circuit name directory

number	circuitname	definition	multiplier
--------	-------------	------------	------------

0 main circuit

1 x0.	clock	1.00
2 x1.	drefresh	1.00
3 x2.	d2load	1.00
4 x3.	d2load	1.00
5 x4.	d2load	1.00
6 x5.	d2load	1.00
7 x0.x0.	csnor	1.00
8 x0.x1.	ssinv	1.00

9 x0.x2.	ssinv	1.00
10 x0.x3.	csnor	1.00
11 x0.x4.	ssinv	1.00
12 x0.x5.	ssinv	1.00
13 x0.x6.	csinv	1.00
14 x0.x7.	delay	1.00
15 x0.x8.	lvl	1.00
16 x0.x9.	lvl	1.00
17 x1.x0.	ss4nand	1.00
18 x1.x1.	sdf	1.00
19 x1.x2.	counter	1.00
20 x1.x3.	dinv	1.00
21 x1.x4.	dinv	1.00
22 x1.x5.	dinv	1.00
23 x1.x6.	dinv	1.00
24 x1.x7.	dd2and	1.00
25 x1.x8.	dd2and	1.00
26 x1.x9.	dd3and	1.00
27 x1.x10.	dd2and	1.00
28 x1.x11.	dd2and	1.00
29 x1.x12.	dd3and	1.00
30 x1.x13.	dd2and	1.00
31 x1.x14.	dd2and	1.00
32 x1.x15.	dd3and	1.00
33 x1.x16.	dd3or	1.00
34 x1.x17.	dd3or	1.00
35 x1.x18.	dd3or	1.00
36 x2.x0.	dinv	1.00
37 x2.x1.	dinv	1.00
38 x3.x0.	dinv	1.00
39 x3.x1.	dinv	1.00
40 x4.x0.	dinv	1.00
41 x4.x1.	dinv	1.00
42 x5.x0.	dinv	1.00
43 x5.x1.	dinv	1.00
44 x0.x7.x0.	bdinv	1.00
45 x0.x7.x1.	bdinv	1.00
46 x0.x7.x2.	bs2and	1.00
47 x0.x8.x0.	dinv	1.00
48 x0.x9.x0.	dinv	1.00
49 x1.x0.x0.	sinv	1.00
50 x1.x0.x1.	sinv	1.00
51 x1.x0.x2.	sinv	1.00
52 x1.x0.x3.	sinv	1.00
53 x1.x0.x4.	s4nor	1.00
54 x1.x0.x5.	sinv	1.00
55 x1.x1.x0.	dlatch	1.00
56 x1.x1.x1.	dinv	1.00
57 x1.x1.x2.	dinv	1.00
58 x1.x1.x3.	sdlatch	1.00
59 x1.x2.x0.	dinv	1.00

60 x1.x2.x1.	dd2and	1.00
61 x1.x2.x2.	dd2and	1.00
62 x1.x2.x3.	dd2or	1.00
63 x1.x2.x4.	dd2and	1.00
64 x1.x2.x5.	dd2and	1.00
65 x1.x2.x6.	dd3and	1.00
66 x1.x2.x7.	dd3or	1.00
67 x1.x2.x8.	dd2and	1.00
68 x1.x2.x9.	dd2and	1.00
69 x1.x2.x10.	dd4and	1.00
70 x1.x2.x11.	dd2and	1.00
71 x1.x2.x12.	dd4or	1.00
72 x1.x2.x13.	cpdff	1.00
73 x1.x2.x14.	cpdff	1.00
74 x1.x2.x15.	cpdff	1.00
75 x1.x7.x0.	dinv	1.00
76 x1.x7.x1.	dinv	1.00
77 x1.x7.x2.	d2nor	1.00
78 x1.x8.x0.	dinv	1.00
79 x1.x8.x1.	dinv	1.00
80 x1.x8.x2.	d2nor	1.00
81 x1.x9.x0.	dinv	1.00
82 x1.x9.x1.	dinv	1.00
83 x1.x9.x2.	dinv	1.00
84 x1.x9.x3.	d3nor	1.00
85 x1.x10.x0.	dinv	1.00
86 x1.x10.x1.	dinv	1.00
87 x1.x10.x2.	d2nor	1.00
88 x1.x11.x0.	dinv	1.00
89 x1.x11.x1.	dinv	1.00
90 x1.x11.x2.	d2nor	1.00
91 x1.x12.x0.	dinv	1.00
92 x1.x12.x1.	dinv	1.00
93 x1.x12.x2.	dinv	1.00
94 x1.x12.x3.	d3nor	1.00
95 x1.x13.x0.	dinv	1.00
96 x1.x13.x1.	dinv	1.00
97 x1.x13.x2.	d2nor	1.00
98 x1.x14.x0.	dinv	1.00
99 x1.x14.x1.	dinv	1.00
100 x1.x14.x2.	d2nor	1.00
101 x1.x15.x0.	dinv	1.00
102 x1.x15.x1.	dinv	1.00
103 x1.x15.x2.	dinv	1.00
104 x1.x15.x3.	d3nor	1.00
105 x1.x16.x0.	d3nor	1.00
106 x1.x16.x1.	dinv	1.00
107 x1.x17.x0.	d3nor	1.00
108 x1.x17.x1.	dinv	1.00
109 x1.x18.x0.	d3nor	1.00
110 x1.x18.x1.	dinv	1.00

111 x0.x7.x2.x0.	bdinv	1.00
112 x0.x7.x2.x1.	bdinv	1.00
113 x0.x7.x2.x2.	bs2nor	1.00
114 x1.x1.x0.x0.	d2nand	1.00
115 x1.x1.x0.x1.	dinv	1.00
116 x1.x1.x0.x2.	d2nand	1.00
117 x1.x1.x0.x3.	d2nand	1.00
118 x1.x1.x0.x4.	d2nand	1.00
119 x1.x1.x3.x0.	d2nand	1.00
120 x1.x1.x3.x1.	dinv	1.00
121 x1.x1.x3.x2.	d2nand	1.00
122 x1.x1.x3.x3.	ss2nand	1.00
123 x1.x1.x3.x4.	ss2nand	1.00
124 x1.x2.x1.x0.	dinv	1.00
125 x1.x2.x1.x1.	dinv	1.00
126 x1.x2.x1.x2.	d2nor	1.00
127 x1.x2.x2.x0.	dinv	1.00
128 x1.x2.x2.x1.	dinv	1.00
129 x1.x2.x2.x2.	d2nor	1.00
130 x1.x2.x3.x0.	d2nor	1.00
131 x1.x2.x3.x1.	dinv	1.00
132 x1.x2.x4.x0.	dinv	1.00
133 x1.x2.x4.x1.	dinv	1.00
134 x1.x2.x4.x2.	d2nor	1.00
135 x1.x2.x5.x0.	dinv	1.00
136 x1.x2.x5.x1.	dinv	1.00
137 x1.x2.x5.x2.	d2nor	1.00
138 x1.x2.x6.x0.	dinv	1.00
139 x1.x2.x6.x1.	dinv	1.00
140 x1.x2.x6.x2.	dinv	1.00
141 x1.x2.x6.x3.	d3nor	1.00
142 x1.x2.x7.x0.	d3nor	1.00
143 x1.x2.x7.x1.	dinv	1.00
144 x1.x2.x8.x0.	dinv	1.00
145 x1.x2.x8.x1.	dinv	1.00
146 x1.x2.x8.x2.	d2nor	1.00
147 x1.x2.x9.x0.	dinv	1.00
148 x1.x2.x9.x1.	dinv	1.00
149 x1.x2.x9.x2.	d2nor	1.00
150 x1.x2.x10.x0.	dinv	1.00
151 x1.x2.x10.x1.	dinv	1.00
152 x1.x2.x10.x2.	dinv	1.00
153 x1.x2.x10.x3.	dinv	1.00
154 x1.x2.x10.x4.	d4nor	1.00
155 x1.x2.x11.x0.	dinv	1.00
156 x1.x2.x11.x1.	dinv	1.00
157 x1.x2.x11.x2.	d2nor	1.00
158 x1.x2.x12.x0.	d4nor	1.00
159 x1.x2.x12.x1.	dinv	1.00
160 x1.x2.x13.x0.	dd2nand	1.00
161 x1.x2.x13.x1.	dd3nand	1.00

162 x1.x2.x13.x2.	dd3nand	1.00
163 x1.x2.x13.x3.	dd3nand	1.00
164 x1.x2.x13.x4.	dd2nand	1.00
165 x1.x2.x13.x5.	dd3nand	1.00
166 x1.x2.x14.x0.	dd2nand	1.00
167 x1.x2.x14.x1.	dd3nand	1.00
168 x1.x2.x14.x2.	dd3nand	1.00
169 x1.x2.x14.x3.	dd3nand	1.00
170 x1.x2.x14.x4.	dd2nand	1.00
171 x1.x2.x14.x5.	dd3nand	1.00
172 x1.x2.x15.x0.	dd2nand	1.00
173 x1.x2.x15.x1.	dd3nand	1.00
174 x1.x2.x15.x2.	dd3nand	1.00
175 x1.x2.x15.x3.	dd3nand	1.00
176 x1.x2.x15.x4.	dd2nand	1.00
177 x1.x2.x15.x5.	dd3nand	1.00
178 x1.x1.x3.x3.x0.	sinv	1.00
179 x1.x1.x3.x3.x1.	sinv	1.00
180 x1.x1.x3.x3.x2.	s2nor	1.00
181 x1.x1.x3.x3.x3.	sinv	1.00
182 x1.x1.x3.x4.x0.	sinv	1.00
183 x1.x1.x3.x4.x1.	sinv	1.00
184 x1.x1.x3.x4.x2.	s2nor	1.00
185 x1.x1.x3.x4.x3.	sinv	1.00
186 x1.x2.x13.x0.x0.	dinv	1.00
187 x1.x2.x13.x0.x1.	dinv	1.00
188 x1.x2.x13.x0.x2.	d2nor	1.00
189 x1.x2.x13.x0.x3.	dinv	1.00
190 x1.x2.x13.x1.x0.	dinv	1.00
191 x1.x2.x13.x1.x1.	dinv	1.00
192 x1.x2.x13.x1.x2.	dinv	1.00
193 x1.x2.x13.x1.x3.	d3nor	1.00
194 x1.x2.x13.x1.x4.	dinv	1.00
195 x1.x2.x13.x2.x0.	dinv	1.00
196 x1.x2.x13.x2.x1.	dinv	1.00
197 x1.x2.x13.x2.x2.	dinv	1.00
198 x1.x2.x13.x2.x3.	d3nor	1.00
199 x1.x2.x13.x2.x4.	dinv	1.00
200 x1.x2.x13.x3.x0.	dinv	1.00
201 x1.x2.x13.x3.x1.	dinv	1.00
202 x1.x2.x13.x3.x2.	dinv	1.00
203 x1.x2.x13.x3.x3.	d3nor	1.00
204 x1.x2.x13.x3.x4.	dinv	1.00
205 x1.x2.x13.x4.x0.	dinv	1.00
206 x1.x2.x13.x4.x1.	dinv	1.00
207 x1.x2.x13.x4.x2.	d2nor	1.00
208 x1.x2.x13.x4.x3.	dinv	1.00
209 x1.x2.x13.x5.x0.	dinv	1.00
210 x1.x2.x13.x5.x1.	dinv	1.00
211 x1.x2.x13.x5.x2.	dinv	1.00
212 x1.x2.x13.x5.x3.	d3nor	1.00

213 x1.x2.x13.x5.x4.	dinv	1.00
214 x1.x2.x14.x0.x0.	dinv	1.00
215 x1.x2.x14.x0.x1.	dinv	1.00
216 x1.x2.x14.x0.x2.	d2nor	1.00
217 x1.x2.x14.x0.x3.	dinv	1.00
218 x1.x2.x14.x1.x0.	dinv	1.00
219 x1.x2.x14.x1.x1.	dinv	1.00
220 x1.x2.x14.x1.x2.	dinv	1.00
221 x1.x2.x14.x1.x3.	d3nor	1.00
222 x1.x2.x14.x1.x4.	dinv	1.00
223 x1.x2.x14.x2.x0.	dinv	1.00
224 x1.x2.x14.x2.x1.	dinv	1.00
225 x1.x2.x14.x2.x2.	dinv	1.00
226 x1.x2.x14.x2.x3.	d3nor	1.00
227 x1.x2.x14.x2.x4.	dinv	1.00
228 x1.x2.x14.x3.x0.	dinv	1.00
229 x1.x2.x14.x3.x1.	dinv	1.00
230 x1.x2.x14.x3.x2.	dinv	1.00
231 x1.x2.x14.x3.x3.	d3nor	1.00
232 x1.x2.x14.x3.x4.	dinv	1.00
233 x1.x2.x14.x4.x0.	dinv	1.00
234 x1.x2.x14.x4.x1.	dinv	1.00
235 x1.x2.x14.x4.x2.	d2nor	1.00
236 x1.x2.x14.x4.x3.	dinv	1.00
237 x1.x2.x14.x5.x0.	dinv	1.00
238 x1.x2.x14.x5.x1.	dinv	1.00
239 x1.x2.x14.x5.x2.	dinv	1.00
240 x1.x2.x14.x5.x3.	d3nor	1.00
241 x1.x2.x14.x5.x4.	dinv	1.00
242 x1.x2.x15.x0.x0.	dinv	1.00
243 x1.x2.x15.x0.x1.	dinv	1.00
244 x1.x2.x15.x0.x2.	d2nor	1.00
245 x1.x2.x15.x0.x3.	dinv	1.00
246 x1.x2.x15.x1.x0.	dinv	1.00
247 x1.x2.x15.x1.x1.	dinv	1.00
248 x1.x2.x15.x1.x2.	dinv	1.00
249 x1.x2.x15.x1.x3.	d3nor	1.00
250 x1.x2.x15.x1.x4.	dinv	1.00
251 x1.x2.x15.x2.x0.	dinv	1.00
252 x1.x2.x15.x2.x1.	dinv	1.00
253 x1.x2.x15.x2.x2.	dinv	1.00
254 x1.x2.x15.x2.x3.	d3nor	1.00
255 x1.x2.x15.x2.x4.	dinv	1.00
256 x1.x2.x15.x3.x0.	dinv	1.00
257 x1.x2.x15.x3.x1.	dinv	1.00
258 x1.x2.x15.x3.x2.	dinv	1.00
259 x1.x2.x15.x3.x3.	d3nor	1.00
260 x1.x2.x15.x3.x4.	dinv	1.00
261 x1.x2.x15.x4.x0.	dinv	1.00
262 x1.x2.x15.x4.x1.	dinv	1.00
263 x1.x2.x15.x4.x2.	d2nor	1.00

264 x1.x2.x15.x4.x3.	dinv	1.00
265 x1.x2.x15.x5.x0.	dinv	1.00
266 x1.x2.x15.x5.x1.	dinv	1.00
267 x1.x2.x15.x5.x2.	dinv	1.00
268 x1.x2.x15.x5.x3.	d3nor	1.00
269 x1.x2.x15.x5.x4.	dinv	1.00

Opening plot unit= 15

file=drefresh1.pa0

```
** hspice file created for circuit drefresh: transient&power @ 25.0c
***** operating point information  tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is 0.
      node =voltage    node =voltage    node =voltage
```

+ 0:1	= 2.0000	0:100	= 63.0000m	0:101	= 63.0000m
+ 0:102	= 63.0000m	0:104	= 31.9639m	0:105	= 720.7624m
+ 0:106	= 758.0773m	0:107	= -1.2402	0:108	= 104.3442m
+ 0:120	= 52.0502m	0:121	= 52.0502m	0:122	= 52.0502m
+ 0:130	= 9.6973u	0:200	= 630.0000m	0:220	= 1.9872
+ 0:221	= 1.9872	0:222	= 1.9872	0:230	= 1.9952
+ 0:777	= -2.5000	0:888	= 2.0000	1:10	= 633.6943m
+ 1:11	= 11.3673m	1:12	= 726.7178m	1:13	= 49.0605m
+ 1:14	= 692.6305m	2:12	= 658.6414m	2:13	= 658.6414m
+ 2:14	= 658.6414m	2:15	= 53.9658m	2:16	= 52.0088m
+ 2:17	= 32.4497m	2:18	= 32.4488m	2:19	= 52.0088m
+ 2:20	= 32.4497m	2:21	= 32.4488m	2:22	= 52.0088m
+ 2:23	= 32.4497m	2:24	= 32.4488m	2:25	= 17.6214u
+ 2:26	= 17.6214u	2:27	= 17.6214u	2:28	= 629.9885m
+ 2:29	= 629.9926m	2:30	= 629.9967m	2:31	= 48.9071u
+ 2:33	= 630.0137m	3:5	= 1.9872	4:5	= 1.9872
+ 5:5	= 1.9872	6:5	= 1.9952	7:8	= 1.2978
+ 8:9	= 53.4430m	9:9	= 1.3829	10:8	= 57.9851m
+ 11:9	= 1.3554	12:9	= 56.8501m	13:9	= 1.3747
+ 14:6	= 636.2190m	14:9	= 58.0085m	15:6	= 1.3578
+ 15:7	= 652.5236m	15:9	= 74.9274m	15:10	= 230.8765m
+ 15:11	= -504.6670m	15:12	= -1.5552	15:13	= -1.8701
+ 15:14	= -2.1851	15:25	= 1.9694	16:6	= -347.6985m
+ 16:7	= -1.0403	16:9	= 1.9988	16:10	= 1.5987
+ 16:11	= 851.5057m	16:12	= -546.7419m	16:13	= -1.1978
+ 16:14	= -1.8489	16:25	= 87.5051m	17:8	= 31.9352m
+ 17:9	= 692.6027m	17:10	= 10.5772m	17:11	= 10.5781m
+ 17:12	= 10.5790m	18:7	= 78.5842m	18:8	= 635.5417m
+ 18:9	= 607.4009m	18:10	= 58.7776m	19:11	= 624.0781m
+ 19:12	= 52.0115m	19:13	= 52.0127m	19:14	= 52.0115m
+ 19:15	= 52.0127m	19:16	= 32.4480m	19:17	= 52.0127m
+ 19:18	= 52.0127m	19:19	= 26.2560m	19:20	= 52.0509m
+ 19:21	= 52.0488m	19:22	= 52.0458m	19:23	= 52.0115m
+ 24:10	= 658.6317m	24:11	= 53.9637m	25:10	= 653.5035m
+ 25:11	= 653.6595m	26:10	= 52.0534m	26:11	= 653.6593m

+ 26:12	= 653.6593m	27:10	= 658.6317m	27:11	= 53.9637m
+ 28:10	= 653.5035m	28:11	= 653.6595m	29:10	= 52.0534m
+ 29:11	= 653.6593m	29:12	= 653.6593m	30:10	= 658.6317m
+ 30:11	= 53.9637m	31:10	= 653.5035m	31:11	= 653.6595m
+ 32:10	= 52.0534m	32:11	= 653.6593m	32:12	= 653.6593m
+ 33:7	= 658.5020m	34:7	= 658.5020m	35:7	= 658.5020m
+ 46:6	= 33.9796m	46:9	= 58.0085m	49:9	= 1.3553
+ 50:9	= 53.9676m	51:9	= 53.9669m	52:9	= 53.9663m
+ 53:8	= 56.8134m	54:9	= 678.3717m	55:7	= 631.5538m
+ 55:8	= 678.6259m	55:9	= 65.8780m	58:7	= 622.4007m
+ 58:8	= 652.8533m	58:9	= 652.6687m	60:10	= 658.7911m
+ 60:11	= 54.9626m	61:10	= 658.7914m	61:11	= 53.9676m
+ 62:6	= 658.5363m	63:10	= 658.7911m	63:11	= 54.9626m
+ 64:10	= 658.7914m	64:11	= 53.9676m	65:10	= 653.6590m
+ 65:11	= 53.9669m	65:12	= 653.6590m	66:7	= 658.4423m
+ 67:10	= 658.7914m	67:11	= 53.9669m	68:10	= 658.7914m
+ 68:11	= 53.9676m	69:10	= 651.6432m	69:11	= 651.6432m
+ 69:12	= 651.6432m	69:13	= 53.9663m	70:10	= 54.9626m
+ 70:11	= 658.7911m	71:8	= 658.3019m	72:9	= 52.0506m
+ 72:10	= 624.0440m	72:11	= 636.5449m	72:12	= 636.5992m
+ 73:9	= 52.0506m	73:10	= 624.0440m	73:11	= 636.5449m
+ 73:12	= 636.5992m	74:9	= 52.0506m	74:10	= 624.0440m
+ 74:11	= 636.5449m	74:12	= 636.5992m	113:8	= 1.4067
+114:6	= 6.0274m	116:6	= 32.7632m	117:6	= 48.4090m
+118:6	= 36.3487m	119:6	= 58.4402m	121:6	= 8.5683m
+122:6	= 10.5824m	122:7	= 684.7784m	122:9	= 16.3579m
+123:6	= 692.7547m	123:7	= 32.0179m	123:9	= 16.3022m
+160:10	= 53.0867m	160:11	= 54.9689m	160:12	= 658.5204m
+161:10	= 651.5335m	161:11	= 651.6421m	161:12	= 651.5924m
+161:13	= 26.2529m	162:10	= 54.9689m	162:11	= 658.7304m
+162:12	= 53.0867m	162:13	= 51.9668m	163:10	= 53.0929m
+163:11	= 653.6561m	163:12	= 653.5469m	163:13	= 32.4387m
+164:10	= 54.9689m	164:11	= 53.9676m	164:12	= 640.4275m
+165:10	= 653.6591m	165:11	= 653.6591m	165:12	= 53.0929m
+165:13	= 32.4484m	166:10	= 53.0867m	166:11	= 54.9689m
+166:12	= 658.5204m	167:10	= 651.5335m	167:11	= 651.6421m
+167:12	= 651.5924m	167:13	= 26.2529m	168:10	= 54.9689m
+168:11	= 658.7304m	168:12	= 53.0867m	168:13	= 51.9668m
+169:10	= 53.0929m	169:11	= 653.6561m	169:12	= 653.5469m
+169:13	= 32.4387m	170:10	= 54.9689m	170:11	= 53.9639m
+170:12	= 640.4275m	171:10	= 653.6591m	171:11	= 653.6591m
+171:12	= 53.0929m	171:13	= 32.4484m	172:10	= 53.0867m
+172:11	= 54.9689m	172:12	= 658.5204m	173:10	= 651.5335m
+173:11	= 651.6421m	173:12	= 651.5924m	173:13	= 26.2529m
+174:10	= 54.9689m	174:11	= 658.7304m	174:12	= 53.0867m
+174:13	= 51.9668m	175:10	= 53.0929m	175:11	= 653.6561m
+175:12	= 653.5469m	175:13	= 32.4387m	176:10	= 54.9689m
+176:11	= 53.9663m	176:12	= 640.4275m	177:10	= 653.6591m
+177:11	= 653.6591m	177:12	= 53.0929m	177:13	= 32.4484m
+178:9	= 52.0275m	179:9	= 53.9637m	180:8	= 1.3479
+181:9	= 55.0192m	182:9	= 52.0302m	183:9	= 1.3559

+184:8 = 56.8710m 185:9 = 1.2949

Opening plot unit= 16
file=drefresh1.tr0

```
** hspice file created for circuit drefresh: transient&power @ 25.0c
***** transient analysis      tnom= 25.000 temp= 25.000
*****
avgpwr    = -4.3741E-01 from= 0.0000E+00  to= 8.0000E-08
vimax     = 6.3000E-01 at= 4.3000E-09
           from= 2.0000E-09 to= 2.0000E-08
vimin     = 6.3000E-02 at= 2.0000E-09
           from= 2.0000E-09 to= 2.0000E-08
vmax      = 6.4008E-01 at= 1.4419E-08
           from= 2.0000E-09 to= 2.0000E-08
vmin      = 5.0554E-02 at= 4.3589E-09
           from= 2.0000E-09 to= 2.0000E-08
tphl      = 1.2046E-09 targ= 3.1349E-08 trig= 3.0145E-08
tplh      = 1.0436E-09 targ= 2.2781E-08 trig= 2.1737E-08
trise     = 3.5483E-10 targ= 2.3016E-08 trig= 2.2661E-08
tfall     = 1.3193E-10 targ= 3.1419E-08 trig= 3.1287E-08
tdelay    = 1.0060E-09 targ= 2.2743E-08 trig= 2.1737E-08
*****
***** job concluded
total cpu time 1930.53 seconds
job started at 20:28:46 3-feb93
job ended at 21:35:50 3-feb93
```

I am done with drefresh1.sp
Wed Feb 3 21:35:51 PST 1993

N. Listing File for DECODDRVER Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
reading design configuration file: ddrver1.cfg
setting user memory from config file to 1000000 words. (8000000 bytes)

```
***** h s p i c e 9007d 18:44:12 4-feb93 sun
** hspice file created for circuit decoddrver: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
```

```

*****
*****
* subcircuit sbfl 2-input nor
*      ina  inb output power ground
.subckt s2nor 1 2 3 4 5
* d g s
j0 8 1 5 0 jfet04 l=1.2 w=48.0
j1 8 2 5 0 jfet04 l=1.2 w=48.0
j2 4 8 8 0 jfet16 l=1.2 w=3.0
j3 4 8 3 0 jfet04 l=1.2 w=48.0
j4 3 2 5 0 jfet04 l=1.2 w=48.0
j5 3 1 5 0 jfet04 l=1.2 w=48.0
.ends s2nor
*****
*****
* subcircuit dcfl with sbfl outputs d flip-flop
***      d clk q /q power ground
.subckt sdff 1 2 3 4 5 6
** sbfl d flip flop
* ina inb d clk q /q out power ground subname
x0 1 9 7 8 5 6 dlatch
x1 2 9 5 6 dinv
x2 9 10 5 6 dinv
x3 7 10 3 4 5 6 sdlatch
.ends sdff
*****
*****
* subcircuit sbfl 4-input nand
*      ina inb inc ind output power ground
.subckt ss4nand 1 2 3 4 5 6 7
* ina inb inc ind out pwr gnd subname
x0 1 9 6 7 sinv
x1 2 10 6 7 sinv
x2 3 11 6 7 sinv
x3 4 12 6 7 sinv
x4 9 10 11 12 8 6 7 s4nor
x5 8 5 6 7 sinv
.ends ss4nand
*****
*****
* subcircuit sbfl 2-input nand
*      ina  inb output power ground
.subckt ss2nand 1 2 3 4 5
* ina inb out pwr gnd subname
x0 1 9 4 5 sinv
x1 2 6 4 5 sinv
x2 9 6 7 4 5 s2nor
x3 7 3 4 5 sinv
.ends ss2nand
*****
*****
```

```

* subcircuit dcfl sd-latch using generic gates
*      d clk q /q power ground
.subckt sdlatch 1 2 3 4 5 6
** sbfl d latch **
* ina inb output power ground subname
x0 1 2 8 5 6 d2nand
x1 1 7 5 6 dinv
x2 2 7 9 5 6 d2nand
x3 8 4 3 5 6 ss2nand
x4 9 3 4 5 6 ss2nand
.ends sdlatch
*****
***** subcircuit dcfl d-latch using generic gates
*      d clk q /q power ground
.subckt dlatch 1 2 3 4 5 6
* ina inb output power ground subname
x0 1 2 8 5 6 d2nand
x1 1 7 5 6 dinv
x2 2 7 9 5 6 d2nand
x3 8 4 3 5 6 d2nand
x4 9 3 4 5 6 d2nand
.ends dlatch
*****
***** hspice dcfl 2-input real nand subcircuit
*      ina, inb, output, power, ground
.subckt d2nand 1 2 3 4 5
* d g s b
j0 4 3 3 5 jfet16 l=1.2 w=6.0
j1 3 1 6 5 jfet04 l=1.2 w=192.0
j2 6 2 5 5 jfet04 l=1.2 w=192.0
.ends d2nand
*****
***** subcircuit sbfl 3-input or
*      ina inb inc output power ground
.subckt s3or 1 2 3 4 5 6
* ina inb inc out pwr gnd subname
x0 1 2 3 7 5 6 s3nor
x1 7 4 5 6 sinv
.ends s3or
*****
***** subcircuit sbfl 4-input and
*      ina inb inc ind output power ground
.subckt ss4and 1 2 3 4 5 6 7
* ina inb inc ind out pwr gnd subname
x0 1 9 6 7 sinv
x1 2 10 6 7 sinv
x2 3 11 6 7 sinv

```

```

x3 4      12 6 7 sinv
x4 9 10 11 12 5 6 7 s4nor
.ends ss4and
*****
*****
* subcircuit sbfl 4-input nor
*      ina inb inc ind output power ground
.subckt s4nor 1 2 3 4 5 6 7
* d g s
j0 8 1 7 0 jfet04 l=1.2 w=48.0
j1 8 2 7 0 jfet04 l=1.2 w=48.0
j2 8 3 7 0 jfet04 l=1.2 w=48.0
j3 8 4 7 0 jfet04 l=1.2 w=48.0
j4 6 8 8 0 jfet16 l=1.2 w=3.0
j5 6 8 5 0 jfet04 l=1.2 w=48.0
j6 5 1 7 0 jfet04 l=1.2 w=48.0
j7 5 2 7 0 jfet04 l=1.2 w=48.0
j8 5 3 7 0 jfet04 l=1.2 w=48.0
j9 5 4 7 0 jfet04 l=1.2 w=48.0
.ends s4nor
*****
*****
* subcircuit sbfl 3-input nor
*      ina inb inc output power ground
.subckt s3nor 1 2 3 4 5 6
* d g s
j0 8 1 6 0 jfet04 l=1.2 w=48.0
j1 8 2 6 0 jfet04 l=1.2 w=48.0
j2 8 3 6 0 jfet04 l=1.2 w=48.0
j3 5 8 8 0 jfet16 l=1.2 w=3.0
j4 5 8 4 0 jfet04 l=1.2 w=48.0
j5 4 1 6 0 jfet04 l=1.2 w=48.0
j6 4 2 6 0 jfet04 l=1.2 w=48.0
j7 4 3 6 0 jfet04 l=1.2 w=48.0
.ends s3nor
*****
*****
* subcircuit sbfl 3-input and
*      ina inb inc output power ground
.subckt ss3and 1 2 3 4 5 6
* ina inb inc out pwr gnd subname
x0 1      9 5 6 sinv
x1 2      10 5 6 sinv
x2 3      11 5 6 sinv
x3 9 10 11 4 5 6 s3nor
.ends ss3and
*****
*****
* subcircuit dcfl 2-input or
*      ina inb output power ground
.subckt dd2or 1 2 3 4 5

```

```

* ina inb out pwr gnd subname
x0 1 2 6 4 5 d2nor
x1 6 3 4 5 dinv
.ends dd2or
*****
***** hspice dcfl 3-input nor subcircuit
*      ina, inb, inc, output, power, ground
.subckt d3nor 1 2 3 4 5 6
* d g s b
j0 5 4 4 6 jfet16 l=1.2 w=6.0
j1 4 1 6 6 jfet04 l=1.2 w=96.0
j2 4 2 6 6 jfet04 l=1.2 w=96.0
j3 4 3 6 6 jfet04 l=1.2 w=96.0
.ends d3nor
*****
* hspice dcfl 3-input demorgan and subcircuit
*      ina, inb, inc, output, power, ground
.subckt dd3and 1 2 3 4 5 6
x0 1 10 5 6 dinv
x1 2 11 5 6 dinv
x2 3 12 5 6 dinv
x3 10 11 12 4 5 6 d3nor
.ends dd3and
*****
* subcircuit dcfl 3-input or
*      ina inb inc output power ground
.subckt dd3or 1 2 3 4 5 6
* ina inb inc out pwr gnd subname
x0 1 2 3 7 5 6 d3nor
x1 7 4 5 6 dinv
.ends dd3or
*****
***** hspice dcfl 4-input nor subcircuit
*      ina, inb, inc, ind, output, power, ground
.subckt d4nor 1 2 3 4 5 6 7
* d g s b
j0 6 5 5 7 jfet16 l=1.2 w=6.0
j1 5 1 7 7 jfet04 l=1.2 w=96.0
j2 5 2 7 7 jfet04 l=1.2 w=96.0
j3 5 3 7 7 jfet04 l=1.2 w=96.0
j4 5 4 7 7 jfet04 l=1.2 w=96.0
.ends d4nor
*****
* subcircuit dcfl 4-input or
*      ina inb inc ind output power ground
.subckt dd4or 1 2 3 4 5 6 7

```

```

* ina inb inc ind out pwr gnd subname
x0 1 2 3 4 8 6 7 d4nor
x1 8      5 6 7 dinv
.ends dd4or
*****
*****  

* hspice dcfl 4-input demorgan and subcircuit
*      ina, inb, inc, ind, output, power, ground
.subckt dd4and 1 2 3 4 5 6 7
x0 1      10 6 7 dinv
x1 2      11 6 7 dinv
x2 3      12 6 7 dinv
x3 4      13 6 7 dinv
x4 10 11 12 13 5 6 7 d4nor
.ends dd4and
*****
*****  

* subcircuit hspice dcfl clear d flip flop
* wakerly pg 363 - 31july 1992
***      d clk clr q /q power ground
.subckt cpdff 1 2 3 4 5 6 7
x0 12 10    9 6 7 dd2nand
x1 9 3 2     10 6 7 dd3nand
x2 10 2 12   11 6 7 dd3nand
x3 11 3 1     12 6 7 dd3nand
x4 10 5      4 6 7 dd2nand
x5 4 3 11    5 6 7 dd3nand
.ends cpdff
*****
*****  

* hspice dcfl 2-input demorgan nand subcircuit
*      ina, inb, output, power, ground
.subckt dd2nand 1 2 3 4 5
x0 1      10 4 5 dinv
x1 2      11 4 5 dinv
x2 10 11 12 4 5 d2nor
x3 12 3 4 5 dinv
.ends dd2nand
*****
*****  

* hspice dcfl 3-input demorgan nand subcircuit
*      ina, inb, inc, output, power, ground
.subckt dd3nand 1 2 3 4 5 6
x0 1      10 5 6 dinv
x1 2      11 5 6 dinv
x2 3      12 5 6 dinv
x3 10 11 12 13 5 6 d3nor
x4 13 4 5 6 dinv
.ends dd3nand
*****

```

```

*****
* hspice dcfl 2-input nor subcircuit
*      ina, inb, output, power, ground
.subckt d2nor  1  2  3  4  5
* d g s b
j0 4 3 3 5 jfet16 l=1.2 w=6.0
j1 3 1 5 5 jfet04 l=1.2 w=96.0
j2 3 2 5 5 jfet04 l=1.2 w=96.0
.ends d2nor
*****
* hspice dcfl 2-input demorgan and subcircuit
*      ina, inb, output, power, ground
.subckt dd2and 1  2  3  4  5
x0 1  10 4 5 dinv
x1 2  11 4 5 dinv
x2 10 11 3 4 5 d2nor
.ends dd2and
*****
***** subcircuit level-shifter to drive dfets
* use hspice diode models for backconnected mesfets
*      input output vds vss
.subckt lvl 1  2  3  4
* d g s b
x0 1 25 3 0 dinv
j1 3 25 6 4 jfet04 l=1.2 w=20.0
j2 7 6 7 4 dio16 l=1.2 w=4.0
j3 7 4 4 4 jfet20 l=3.0 w=3.0
j4 3 9 9 4 jfet16 l=1.2 w=3.0
j5 9 7 0 4 jfet16 l=1.2 w=10.0
j6 3 9 10 4 jfet16 l=1.2 w=20.0
j7 11 10 11 4 dio16 l=1.2 w=20.0
j8 2 11 2 4 dio16 l=1.2 w=20.0
j9 2 4 4 4 jfet16 l=1.2 w=12.0
j10 12 2 12 4 dio16 l=1.2 w=10.0
j11 13 12 13 4 dio16 l=1.2 w=10.0
j12 14 13 14 4 dio16 l=1.2 w=10.0
j13 4 14 4 4 dio16 l=1.2 w=10.0
.ends lvl
*****
***** hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt bdinv 1  2  3  4
* d g s b
j0 3 2 2 4 jfet20 l=3.0 w=40.0
j1 2 1 4 4 jfet04 l=1.2 w=240.0
.ends bdinv
*****
* subcircuit sbfl 2-input nor
*      ina  inb output power ground

```

```

.subckt bs2nor 1 2 3 4 5
* d g s
j0 8 1 5 0 jfet04 l=1.2 w=180.0
j1 8 2 5 0 jfet04 l=1.2 w=180.0
j2 4 8 8 0 jfet16 l=1.2 w=10.0
j3 4 8 3 0 jfet04 l=1.2 w=224.0
j4 3 2 5 0 jfet04 l=1.2 w=224.0
j5 3 1 5 0 jfet04 l=1.2 w=224.0
.ends bs2nor
*****
* subcircuit sbfl 2- input and
*      ina  inb output power ground
.subckt bs2and 1 2 3 4 5
* ina inb out pwr gnd subname
x0 1 9 4 5 bdinv
x1 2 6 4 5 bdinv
x2 9 6 3 4 5 bs2nor
.ends bs2and
*****
* subckt hspice sbfl large 2-input nor
*      ina  inb output power ground
.subckt csnor 1 2 3 4 5
* d g s b
j0 8 1 5 0 jfet04 l=1.2 w=144.0
j1 8 2 5 0 jfet04 l=1.2 w=144.0
j2 4 8 8 0 jfet16 l=1.2 w= 9.0
j3 4 8 3 0 jfet04 l=1.2 w=144.0
j4 3 2 5 0 jfet04 l=1.2 w=144.0
j5 3 1 5 0 jfet04 l=1.2 w=144.0
.ends csnor
*****
* hspice sbfl extra-large driver-inverter subcircuit
*      input, output, power, ground
.subckt ssinv 1 2 3 4
* d g s b
j0 9 1 4 0 jfet04 l=1.2 w=768.0
j1 3 9 9 0 jfet16 l=1.2 w= 48.0
j2 3 9 2 0 jfet04 l=1.2 w=768.0
j3 2 1 4 0 jfet04 l=1.2 w=768.0
.ends ssinv
*****
* hspice sbfl large driver-inverter subcircuit
*      input, output, power, ground
.subckt csinv 1 2 3 4
* d g s b
j0 9 1 4 0 jfet04 l=1.2 w=256.0
j1 3 9 9 0 jfet16 l=1.2 w= 16.0
j2 3 9 2 0 jfet04 l=1.2 w=384.0
j3 2 1 4 0 jfet04 l=1.2 w=384.0

```

```

.ends csinv
*****
* subcircuit delay generates fee d
*      input output power ground
.subckt delay 1 2 3 4
* ina inb     out   power ground subname
x0 1         9 3 4 bdinv
x1 9         6 3 4 bdinv
x2 1 6       2 3 4 bs2and
.ends delay
*****
* subcircuit for hspice two-phase sbfl clock
*      inclk ph1 ph2 ph2d ph11 ph2ld power1 power2 ground
.subckt clock 1 2 3 4 5 6 7 8 9
* ina inb out pwr gnd subname
x0 1 2 10 7 9 csnor
x1 10 11 7 9 ssinv
x2 11 3 7 9 ssinv
x3 12 3 13 7 9 csnor
x4 13 14 7 9 ssinv
x5 14 2 7 9 ssinv
x6 1 12 7 9 csinv
x7 3 4 7 9 delay
x8 2 5 7 8 lvl
x9 4 6 7 8 lvl
.ends clock
*****
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
* hspice d mesfet load subcircuit
*      input, power, ground
.subckt dm10load 1 3 4
j0 3 1 4 4 jfet16 l=1.2 w= 10.0
j1 3 1 4 4 jfet16 l=1.2 w= 10.0
j2 3 1 4 4 jfet16 l=1.2 w= 10.0
j3 3 1 4 4 jfet16 l=1.2 w= 10.0
j4 3 1 4 4 jfet16 l=1.2 w= 10.0
j5 3 1 4 4 jfet16 l=1.2 w= 10.0
j6 3 1 4 4 jfet16 l=1.2 w= 10.0
j7 3 1 4 4 jfet16 l=1.2 w= 10.0
j8 3 1 4 4 jfet16 l=1.2 w= 10.0
j9 3 1 4 4 jfet16 l=1.2 w= 10.0
.ends dm10load
*****

```

```

*****
* subcircuit sbfl inverter
*      input, output, power, ground
.subckt sinv 1 2 3 4
* d g s
j0 9 1 4 0 jfet04 l=1.2 w=48.0
j1 3 9 9 0 jfet16 l=1.2 w=3.0
j2 3 9 2 0 jfet04 l=1.2 w=48.0
j3 2 1 4 0 jfet04 l=1.2 w=48.0
.ends sinv
*****
***** hspice sbfl standard load subcircuit
*      input, output, power, ground
.subckt s10load 1 2 3 4
x0 1 5 3 4 sinv
x1 1 2 3 4 sinv
x2 1 6 3 4 sinv
x3 1 7 3 4 sinv
x4 1 8 3 4 sinv
x5 1 9 3 4 sinv
x6 1 10 3 4 sinv
x7 1 11 3 4 sinv
x8 1 12 3 4 sinv
x9 1 13 3 4 sinv
.ends s10load
*****
***** subcircuit dcfl counter using clear/preset d fps - cpdff
***      enble clk q0 q1 q2 /q0 /q1 /q2 power ground
.subckt counter 1 2 3 4 5 6 7 8 9 10
*** ina inb inc ind d clk q /q out power ground subname
x0 1           11 9 10 dinv
x1 3 11         12 9 10 dd2and
x2 1 6          13 9 10 dd2and
x3 12 13        20 9 10 dd2or
x4 4 11         14 9 10 dd2and
x5 4 6          15 9 10 dd2and
x6 3 7 1         16 9 10 dd3and
x7 14 15 16      21 9 10 dd3or
x8 5 7          17 9 10 dd2and
x9 5 6          18 9 10 dd2and
x10 1 3 4 8       19 9 10 dd4and
x11 11 5         23 9 10 dd2and
x12 17 18 19 23    22 9 10 dd4or
x13 20 2 1       3 6   9 10 cpdff
x14 21 2 1       4 7   9 10 cpdff
x15 22 2 1       5 8   9 10 cpdff
.ends counter
*****

```

```

* subcircuit non-latched sbfl/dcfl combination decoder
****      a0 a1 a2 w r re o0 o1 o2 o3 o4 o5 o6 o7 enbl pwr grnd
.subckt decoder 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
*   ina inb inc ind    output power ground subname
x1 1          20 16 17 dinv
x2 2          18 16 17 dinv
x3 3          19 16 17 dinv
x4 4 5 6      15 16 17 s3or
x5 20 18 19 15 7 16 17 ss4and
x6 1 18 19 15 8 16 17 ss4and
x7 20 2 19 15 9 16 17 ss4and
x8 1 2 19 15 10 16 17 ss4and
x9 20 18 3 15 11 16 17 ss4and
x10 1 18 3 15 12 16 17 ss4and
x11 20 2 3 15 13 16 17 ss4and
x12 1 2 3 15 14 16 17 ss4and
.ends decoder
*****
***** subcircuit dcfl/sbfl combination refresh circuit
* refresh ph 1 clock a0 a1 a2 ao0 ao1 ao2 mrefresh power ground
.subckt drefresh 1 2 3 4 5 6 7 8 9 10 11
*** ina inb inc ind d clk q /q out power ground subname
x0 15 28 29 30      31 10 11 ss4nand
x1 31 2          9 33 10 11 sdff
x2 31 2 25 26 27 28 29 30 10 11 counter
x3 3          12 10 11 dinv
x4 4          13 10 11 dinv
x5 5          14 10 11 dinv
x6 1          15 10 11 dinv
x7 3 33        16 10 11 dd2and
x8 3 25        17 10 11 dd2and
x9 12 25 9     18 10 11 dd3and
x10 4 33       19 10 11 dd2and
x11 4 26       20 10 11 dd2and
x12 13 26 9     21 10 11 dd3and
x13 5 33       22 10 11 dd2and
x14 5 27       23 10 11 dd2and
x15 14 27 9     24 10 11 dd3and
x16 16 17 18     6 10 11 dd3or
x17 19 20 21     7 10 11 dd3or
x18 22 23 24     8 10 11 dd3or
.ic v(25)=0.0 v(26)=0.0 v(27)=0.0 v(31)=0.0 v(9)=0.0
+ v(28)=0.63 v(29)=0.63 v(30)=0.63 v(33)=0.63
.ends drefresh
*****
***** subcircuit decoder/driver 'decoddrver'
** 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
** ph2d ao0 ao1 ao2 mref mr mw da0 da1 da2 da3 da4 da5 da6 da7 evu odu ev od pw

```

```

.subckt decoddrver 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
*** ina inb inc ind d clk q /q out enbl pwr bulk subname
x0 2 3 4 7 6 5 30 31 32 33 34 35 36 37 50 20 22 decoder
x1 2 48 20 22 dinv
x2 2 1 50 17 20 22 ss3and
x3 48 1 50 16 20 22 ss3and
x4 30 1 40 20 22 dd2and
x5 31 1 41 20 22 dd2and
x6 32 1 42 20 22 dd2and
x7 33 1 43 20 22 dd2and
x8 34 1 44 20 22 dd2and
x9 35 1 45 20 22 dd2and
x10 36 1 46 20 22 dd2and
x11 37 1 47 20 22 dd2and
x12 40 8 20 21 lvl
x13 41 9 20 21 lvl
x14 42 10 20 21 lvl
x15 43 11 20 21 lvl
x16 44 12 20 21 lvl
x17 45 13 20 21 lvl
x18 46 14 20 21 lvl
x19 47 15 20 21 lvl
x20 16 18 20 21 lvl
x21 17 19 20 21 lvl
.ends decoddrver
*****
```

* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.

* power supplies
vds 1 0 dc 2.0v \$ element under test power supply
vss 777 0 dc -2.5v \$ test load negative power supply
vload 888 0 dc 2.0v \$ test load power supply

* temperature card
*.temp 85.0

* signal inputs

* next three lines used to provide test signal inputs for transient analysis
va0 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
va1 101 0 pulse(0.063 0.63 8400ps 100ps 100ps 8200ps 16800ps)
va2 102 0 pulse(0.063 0.63 16800ps 100ps 100ps 16600ps 33600ps)
vref 200 0 pulse(0.63 0.063 63600ps 100ps 100ps 63400ps 87200ps)
vmr 201 0 0.063v
vmw 202 0 0.063v

*inclk ph1 ph2 ph2d ph11 ph2ld power1 power2 ground
x0 100 104 105 106 107 108 888 777 0 clock

* ref ph1 a0 a1 a2 a00 a01 a02 mrefresh pwr gnd

```

x1 200 104 100 101 102 120 121 122 130 888 0 drefresh
*****
** ph2d ao0 ao1 ao2 mref mr mw da0 da1 da2 da3 da4 da5 da6 da7 evu odu ev od
x2 106 120 121 122 130 201 202 150 151 152 153 154 155 156 157 160 161 170 171
* pwr1 pwr2 gnd subname
+ 1 777 0 decoddrver

* measurement parameters

* next lines are used for transient analysis
.probe ao0=v(120) ao1=v(121) ao2=v(122) mref=v(130)
+ ph2d=v(106) da0=v(150) da1=v(151) da2=v(152) da3=v(153) da4=v(154) da5=v(155)
+ da6=v(156) da7=v(157) evu=v(160) odu=v(161) ev=v(170) od=v(171)
.probe tran p(vds) p(vss) power
.measure tran avgpwr avg p(vds)

* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis
.meas tran vmax max v(120) from=2ns to=88ns
.meas tran vmin min v(120) from=2ns to=88ns
.meas tran tphl trig v(106) val='(vmax-vmin)*.5' td=12ns
+ fall=1 targ v(120) val='(vmax-vmin)*.5' td=12ns fall=1
.meas tran tplh trig v(106) val='(vmax-vmin)*.5' td=12ns
+ fall=1 targ v(121) val='(vmax-vmin)*.5' td=12ns rise=1
.meas tran trise trig v(121) val='vmin+0.1*vmax' td=12ns
+ rise=1 targ v(121) val='0.9*vmax' rise=1
.meas tran tfall trig v(120) val='0.9*vmax' td=12ns
+ fall=1 targ v(120) val='vmin+0.1*vmax' td=12ns fall=1
.meas tran tdelay trig v(106) val=.2835 td=12ns fall=1
+ targ v(120) val=.2835 td=12ns fall=1
.tran 1500ps 88ns
.options scale=1e-06 brief=0 nopage measout post probe
.end
** hspice file created for circuit decoddrver: transient&power @ 25.0c
***** circuit name directory
*****
circuit number to circuit name directory
number circuitname definition multiplier
 0 main circuit
 1 x0.          clock    1.00
 2 x1.          drefresh 1.00
 3 x2.          decoddrver 1.00
 4 x0.x0.        csnor    1.00
 5 x0.x1.        ssinv    1.00
 6 x0.x2.        ssinv    1.00
 7 x0.x3.        csnor    1.00
 8 x0.x4.        ssinv    1.00
 9 x0.x5.        ssinv    1.00
10 x0.x6.        ssinv    1.00
11 x0.x7.        delay    1.00
12 x0.x8.        lvl      1.00

```

13 x0.x9.	lvl	1.00
14 x1.x0.	ss4nand	1.00
15 x1.x1.	sdff	1.00
16 x1.x2.	counter	1.00
17 x1.x3.	dinv	1.00
18 x1.x4.	dinv	1.00
19 x1.x5.	dinv	1.00
20 x1.x6.	dinv	1.00
21 x1.x7.	dd2and	1.00
22 x1.x8.	dd2and	1.00
23 x1.x9.	dd3and	1.00
24 x1.x10.	dd2and	1.00
25 x1.x11.	dd2and	1.00
26 x1.x12.	dd3and	1.00
27 x1.x13.	dd2and	1.00
28 x1.x14.	dd2and	1.00
29 x1.x15.	dd3and	1.00
30 x1.x16.	dd3or	1.00
31 x1.x17.	dd3or	1.00
32 x1.x18.	dd3or	1.00
33 x2.x0.	decoder	1.00
34 x2.x1.	dinv	1.00
35 x2.x2.	ss3and	1.00
36 x2.x3.	ss3and	1.00
37 x2.x4.	dd2and	1.00
38 x2.x5.	dd2and	1.00
39 x2.x6.	dd2and	1.00
40 x2.x7.	dd2and	1.00
41 x2.x8.	dd2and	1.00
42 x2.x9.	dd2and	1.00
43 x2.x10.	dd2and	1.00
44 x2.x11.	dd2and	1.00
45 x2.x12.	lvl	1.00
46 x2.x13.	lvl	1.00
47 x2.x14.	lvl	1.00
48 x2.x15.	lvl	1.00
49 x2.x16.	lvl	1.00
50 x2.x17.	lvl	1.00
51 x2.x18.	lvl	1.00
52 x2.x19.	lvl	1.00
53 x2.x20.	lvl	1.00
54 x2.x21.	lvl	1.00
55 x0.x7.x0.	bdinv	1.00
56 x0.x7.x1.	bdinv	1.00
57 x0.x7.x2.	bs2and	1.00
58 x0.x8.x0.	dinv	1.00
59 x0.x9.x0.	dinv	1.00
60 x1.x0.x0.	sinv	1.00
61 x1.x0.x1.	sinv	1.00
62 x1.x0.x2.	sinv	1.00
63 x1.x0.x3.	sinv	1.00

64 x1.x0.x4.	s4nor	1.00
65 x1.x0.x5.	sinv	1.00
66 x1.x1.x0.	dlatch	1.00
67 x1.x1.x1.	dinv	1.00
68 x1.x1.x2.	dinv	1.00
69 x1.x1.x3.	sdlatch	1.00
70 x1.x2.x0.	dinv	1.00
71 x1.x2.x1.	dd2and	1.00
72 x1.x2.x2.	dd2and	1.00
73 x1.x2.x3.	dd2or	1.00
74 x1.x2.x4.	dd2and	1.00
75 x1.x2.x5.	dd2and	1.00
76 x1.x2.x6.	dd3and	1.00
77 x1.x2.x7.	dd3or	1.00
78 x1.x2.x8.	dd2and	1.00
79 x1.x2.x9.	dd2and	1.00
80 x1.x2.x10.	dd4and	1.00
81 x1.x2.x11.	dd2and	1.00
82 x1.x2.x12.	dd4or	1.00
83 x1.x2.x13.	cpdff	1.00
84 x1.x2.x14.	cpdff	1.00
85 x1.x2.x15.	cpdff	1.00
86 x1.x7.x0.	dinv	1.00
87 x1.x7.x1.	dinv	1.00
88 x1.x7.x2.	d2nor	1.00
89 x1.x8.x0.	dinv	1.00
90 x1.x8.x1.	dinv	1.00
91 x1.x8.x2.	d2nor	1.00
92 x1.x9.x0.	dinv	1.00
93 x1.x9.x1.	dinv	1.00
94 x1.x9.x2.	dinv	1.00
95 x1.x9.x3.	d3nor	1.00
96 x1.x10.x0.	dinv	1.00
97 x1.x10.x1.	dinv	1.00
98 x1.x10.x2.	d2nor	1.00
99 x1.x11.x0.	dinv	1.00
100 x1.x11.x1.	dinv	1.00
101 x1.x11.x2.	d2nor	1.00
102 x1.x12.x0.	dinv	1.00
103 x1.x12.x1.	dinv	1.00
104 x1.x12.x2.	dinv	1.00
105 x1.x12.x3.	d3nor	1.00
106 x1.x13.x0.	dinv	1.00
107 x1.x13.x1.	dinv	1.00
108 x1.x13.x2.	d2nor	1.00
109 x1.x14.x0.	dinv	1.00
110 x1.x14.x1.	dinv	1.00
111 x1.x14.x2.	d2nor	1.00
112 x1.x15.x0.	dinv	1.00
113 x1.x15.x1.	dinv	1.00
114 x1.x15.x2.	dinv	1.00

115 x1.x15.x3.	d3nor	1.00
116 x1.x16.x0.	d3nor	1.00
117 x1.x16.x1.	dinv	1.00
118 x1.x17.x0.	d3nor	1.00
119 x1.x17.x1.	dinv	1.00
120 x1.x18.x0.	d3nor	1.00
121 x1.x18.x1.	dinv	1.00
122 x2.x0.x1.	dinv	1.00
123 x2.x0.x2.	dinv	1.00
124 x2.x0.x3.	dinv	1.00
125 x2.x0.x4.	s3or	1.00
126 x2.x0.x5.	ss4and	1.00
127 x2.x0.x6.	ss4and	1.00
128 x2.x0.x7.	ss4and	1.00
129 x2.x0.x8.	ss4and	1.00
130 x2.x0.x9.	ss4and	1.00
131 x2.x0.x10.	ss4and	1.00
132 x2.x0.x11.	ss4and	1.00
133 x2.x0.x12.	ss4and	1.00
134 x2.x2.x0.	sinv	1.00
135 x2.x2.x1.	sinv	1.00
136 x2.x2.x2.	sinv	1.00
137 x2.x2.x3.	s3nor	1.00
138 x2.x3.x0.	sinv	1.00
139 x2.x3.x1.	sinv	1.00
140 x2.x3.x2.	sinv	1.00
141 x2.x3.x3.	s3nor	1.00
142 x2.x4.x0.	dinv	1.00
143 x2.x4.x1.	dinv	1.00
144 x2.x4.x2.	d2nor	1.00
145 x2.x5.x0.	dinv	1.00
146 x2.x5.x1.	dinv	1.00
147 x2.x5.x2.	d2nor	1.00
148 x2.x6.x0.	dinv	1.00
149 x2.x6.x1.	dinv	1.00
150 x2.x6.x2.	d2nor	1.00
151 x2.x7.x0.	dinv	1.00
152 x2.x7.x1.	dinv	1.00
153 x2.x7.x2.	d2nor	1.00
154 x2.x8.x0.	dinv	1.00
155 x2.x8.x1.	dinv	1.00
156 x2.x8.x2.	d2nor	1.00
157 x2.x9.x0.	dinv	1.00
158 x2.x9.x1.	dinv	1.00
159 x2.x9.x2.	d2nor	1.00
160 x2.x10.x0.	dinv	1.00
161 x2.x10.x1.	dinv	1.00
162 x2.x10.x2.	d2nor	1.00
163 x2.x11.x0.	dinv	1.00
164 x2.x11.x1.	dinv	1.00
165 x2.x11.x2.	d2nor	1.00

166 x2.x12.x0.	dinv	1.00
167 x2.x13.x0.	dinv	1.00
168 x2.x14.x0.	dinv	1.00
169 x2.x15.x0.	dinv	1.00
170 x2.x16.x0.	dinv	1.00
171 x2.x17.x0.	dinv	1.00
172 x2.x18.x0.	dinv	1.00
173 x2.x19.x0.	dinv	1.00
174 x2.x20.x0.	dinv	1.00
175 x2.x21.x0.	dinv	1.00
176 x0.x7.x2.x0.	bdiv	1.00
177 x0.x7.x2.x1.	bdiv	1.00
178 x0.x7.x2.x2.	bs2nor	1.00
179 x1.x1.x0.x0.	d2nand	1.00
180 x1.x1.x0.x1.	dinv	1.00
181 x1.x1.x0.x2.	d2nand	1.00
182 x1.x1.x0.x3.	d2nand	1.00
183 x1.x1.x0.x4.	d2nand	1.00
184 x1.x1.x3.x0.	d2nand	1.00
185 x1.x1.x3.x1.	dinv	1.00
186 x1.x1.x3.x2.	d2nand	1.00
187 x1.x1.x3.x3.	ss2nand	1.00
188 x1.x1.x3.x4.	ss2nand	1.00
189 x1.x2.x1.x0.	dinv	1.00
190 x1.x2.x1.x1.	dinv	1.00
191 x1.x2.x1.x2.	d2nor	1.00
192 x1.x2.x2.x0.	dinv	1.00
193 x1.x2.x2.x1.	dinv	1.00
194 x1.x2.x2.x2.	d2nor	1.00
195 x1.x2.x3.x0.	d2nor	1.00
196 x1.x2.x3.x1.	dinv	1.00
197 x1.x2.x4.x0.	dinv	1.00
198 x1.x2.x4.x1.	dinv	1.00
199 x1.x2.x4.x2.	d2nor	1.00
200 x1.x2.x5.x0.	dinv	1.00
201 x1.x2.x5.x1.	dinv	1.00
202 x1.x2.x5.x2.	d2nor	1.00
203 x1.x2.x6.x0.	dinv	1.00
204 x1.x2.x6.x1.	dinv	1.00
205 x1.x2.x6.x2.	dinv	1.00
206 x1.x2.x6.x3.	d3nor	1.00
207 x1.x2.x7.x0.	d3nor	1.00
208 x1.x2.x7.x1.	dinv	1.00
209 x1.x2.x8.x0.	dinv	1.00
210 x1.x2.x8.x1.	dinv	1.00
211 x1.x2.x8.x2.	d2nor	1.00
212 x1.x2.x9.x0.	dinv	1.00
213 x1.x2.x9.x1.	dinv	1.00
214 x1.x2.x9.x2.	d2nor	1.00
215 x1.x2.x10.x0.	dinv	1.00
216 x1.x2.x10.x1.	dinv	1.00

217 x1.x2.x10.x2.	dinv	1.00
218 x1.x2.x10.x3.	dinv	1.00
219 x1.x2.x10.x4.	d4nor	1.00
220 x1.x2.x11.x0.	dinv	1.00
221 x1.x2.x11.x1.	dinv	1.00
222 x1.x2.x11.x2.	d2nor	1.00
223 x1.x2.x12.x0.	d4nor	1.00
224 x1.x2.x12.x1.	dinv	1.00
225 x1.x2.x13.x0.	dd2nand	1.00
226 x1.x2.x13.x1.	dd3nand	1.00
227 x1.x2.x13.x2.	dd3nand	1.00
228 x1.x2.x13.x3.	dd3nand	1.00
229 x1.x2.x13.x4.	dd2nand	1.00
230 x1.x2.x13.x5.	dd3nand	1.00
231 x1.x2.x14.x0.	dd2nand	1.00
232 x1.x2.x14.x1.	dd3nand	1.00
233 x1.x2.x14.x2.	dd3nand	1.00
234 x1.x2.x14.x3.	dd3nand	1.00
235 x1.x2.x14.x4.	dd2nand	1.00
236 x1.x2.x14.x5.	dd3nand	1.00
237 x1.x2.x15.x0.	dd2nand	1.00
238 x1.x2.x15.x1.	dd3nand	1.00
239 x1.x2.x15.x2.	dd3nand	1.00
240 x1.x2.x15.x3.	dd3nand	1.00
241 x1.x2.x15.x4.	dd2nand	1.00
242 x1.x2.x15.x5.	dd3nand	1.00
243 x2.x0.x4.x0.	s3nor	1.00
244 x2.x0.x4.x1.	sinv	1.00
245 x2.x0.x5.x0.	sinv	1.00
246 x2.x0.x5.x1.	sinv	1.00
247 x2.x0.x5.x2.	sinv	1.00
248 x2.x0.x5.x3.	sinv	1.00
249 x2.x0.x5.x4.	s4nor	1.00
250 x2.x0.x6.x0.	sinv	1.00
251 x2.x0.x6.x1.	sinv	1.00
252 x2.x0.x6.x2.	sinv	1.00
253 x2.x0.x6.x3.	sinv	1.00
254 x2.x0.x6.x4.	s4nor	1.00
255 x2.x0.x7.x0.	sinv	1.00
256 x2.x0.x7.x1.	sinv	1.00
257 x2.x0.x7.x2.	sinv	1.00
258 x2.x0.x7.x3.	sinv	1.00
259 x2.x0.x7.x4.	s4nor	1.00
260 x2.x0.x8.x0.	sinv	1.00
261 x2.x0.x8.x1.	sinv	1.00
262 x2.x0.x8.x2.	sinv	1.00
263 x2.x0.x8.x3.	sinv	1.00
264 x2.x0.x8.x4.	s4nor	1.00
265 x2.x0.x9.x0.	sinv	1.00
266 x2.x0.x9.x1.	sinv	1.00
267 x2.x0.x9.x2.	sinv	1.00

268 x2.x0.x9.x3.	sinv	1.00
269 x2.x0.x9.x4.	s4nor	1.00
270 x2.x0.x10.x0.	sinv	1.00
271 x2.x0.x10.x1.	sinv	1.00
272 x2.x0.x10.x2.	sinv	1.00
273 x2.x0.x10.x3.	sinv	1.00
274 x2.x0.x10.x4.	s4nor	1.00
275 x2.x0.x11.x0.	sinv	1.00
276 x2.x0.x11.x1.	sinv	1.00
277 x2.x0.x11.x2.	sinv	1.00
278 x2.x0.x11.x3.	sinv	1.00
279 x2.x0.x11.x4.	s4nor	1.00
280 x2.x0.x12.x0.	sinv	1.00
281 x2.x0.x12.x1.	sinv	1.00
282 x2.x0.x12.x2.	sinv	1.00
283 x2.x0.x12.x3.	sinv	1.00
284 x2.x0.x12.x4.	s4nor	1.00
285 x1.x1.x3.x3.x0.	sinv	1.00
286 x1.x1.x3.x3.x1.	sinv	1.00
287 x1.x1.x3.x3.x2.	s2nor	1.00
288 x1.x1.x3.x3.x3.	sinv	1.00
289 x1.x1.x3.x4.x0.	sinv	1.00
290 x1.x1.x3.x4.x1.	sinv	1.00
291 x1.x1.x3.x4.x2.	s2nor	1.00
292 x1.x1.x3.x4.x3.	sinv	1.00
293 x1.x2.x13.x0.x0.	dinv	1.00
294 x1.x2.x13.x0.x1.	dinv	1.00
295 x1.x2.x13.x0.x2.	d2nor	1.00
296 x1.x2.x13.x0.x3.	dinv	1.00
297 x1.x2.x13.x1.x0.	dinv	1.00
298 x1.x2.x13.x1.x1.	dinv	1.00
299 x1.x2.x13.x1.x2.	dinv	1.00
300 x1.x2.x13.x1.x3.	d3nor	1.00
301 x1.x2.x13.x1.x4.	dinv	1.00
302 x1.x2.x13.x2.x0.	dinv	1.00
303 x1.x2.x13.x2.x1.	dinv	1.00
304 x1.x2.x13.x2.x2.	dinv	1.00
305 x1.x2.x13.x2.x3.	d3nor	1.00
306 x1.x2.x13.x2.x4.	dinv	1.00
307 x1.x2.x13.x3.x0.	dinv	1.00
308 x1.x2.x13.x3.x1.	dinv	1.00
309 x1.x2.x13.x3.x2.	dinv	1.00
310 x1.x2.x13.x3.x3.	d3nor	1.00
311 x1.x2.x13.x3.x4.	dinv	1.00
312 x1.x2.x13.x4.x0.	dinv	1.00
313 x1.x2.x13.x4.x1.	dinv	1.00
314 x1.x2.x13.x4.x2.	d2nor	1.00
315 x1.x2.x13.x4.x3.	dinv	1.00
316 x1.x2.x13.x5.x0.	dinv	1.00
317 x1.x2.x13.x5.x1.	dinv	1.00
318 x1.x2.x13.x5.x2.	dinv	1.00

319 x1.x2.x13.x5.x3.	d3nor	1.00
320 x1.x2.x13.x5.x4.	dinv	1.00
321 x1.x2.x14.x0.x0.	dinv	1.00
322 x1.x2.x14.x0.x1.	dinv	1.00
323 x1.x2.x14.x0.x2.	d2nor	1.00
324 x1.x2.x14.x0.x3.	dinv	1.00
325 x1.x2.x14.x1.x0.	dinv	1.00
326 x1.x2.x14.x1.x1.	dinv	1.00
327 x1.x2.x14.x1.x2.	dinv	1.00
328 x1.x2.x14.x1.x3.	d3nor	1.00
329 x1.x2.x14.x1.x4.	dinv	1.00
330 x1.x2.x14.x2.x0.	dinv	1.00
331 x1.x2.x14.x2.x1.	dinv	1.00
332 x1.x2.x14.x2.x2.	dinv	1.00
333 x1.x2.x14.x2.x3.	d3nor	1.00
334 x1.x2.x14.x2.x4.	dinv	1.00
335 x1.x2.x14.x3.x0.	dinv	1.00
336 x1.x2.x14.x3.x1.	dinv	1.00
337 x1.x2.x14.x3.x2.	dinv	1.00
338 x1.x2.x14.x3.x3.	d3nor	1.00
339 x1.x2.x14.x3.x4.	dinv	1.00
340 x1.x2.x14.x4.x0.	dinv	1.00
341 x1.x2.x14.x4.x1.	dinv	1.00
342 x1.x2.x14.x4.x2.	d2nor	1.00
343 x1.x2.x14.x4.x3.	dinv	1.00
344 x1.x2.x14.x5.x0.	dinv	1.00
345 x1.x2.x14.x5.x1.	dinv	1.00
346 x1.x2.x14.x5.x2.	dinv	1.00
347 x1.x2.x14.x5.x3.	d3nor	1.00
348 x1.x2.x14.x5.x4.	dinv	1.00
349 x1.x2.x15.x0.x0.	dinv	1.00
350 x1.x2.x15.x0.x1.	dinv	1.00
351 x1.x2.x15.x0.x2.	d2nor	1.00
352 x1.x2.x15.x0.x3.	dinv	1.00
353 x1.x2.x15.x1.x0.	dinv	1.00
354 x1.x2.x15.x1.x1.	dinv	1.00
355 x1.x2.x15.x1.x2.	dinv	1.00
356 x1.x2.x15.x1.x3.	d3nor	1.00
357 x1.x2.x15.x1.x4.	dinv	1.00
358 x1.x2.x15.x2.x0.	dinv	1.00
359 x1.x2.x15.x2.x1.	dinv	1.00
360 x1.x2.x15.x2.x2.	dinv	1.00
361 x1.x2.x15.x2.x3.	d3nor	1.00
362 x1.x2.x15.x2.x4.	dinv	1.00
363 x1.x2.x15.x3.x0.	dinv	1.00
364 x1.x2.x15.x3.x1.	dinv	1.00
365 x1.x2.x15.x3.x2.	dinv	1.00
366 x1.x2.x15.x3.x3.	d3nor	1.00
367 x1.x2.x15.x3.x4.	dinv	1.00
368 x1.x2.x15.x4.x0.	dinv	1.00
369 x1.x2.x15.x4.x1.	dinv	1.00

370 x1.x2.x15.x4.x2. d2nor 1.00
 371 x1.x2.x15.x4.x3. dinv 1.00
 372 x1.x2.x15.x5.x0. dinv 1.00
 373 x1.x2.x15.x5.x1. dinv 1.00
 374 x1.x2.x15.x5.x2. dinv 1.00
 375 x1.x2.x15.x5.x3. d3nor 1.00
 376 x1.x2.x15.x5.x4. dinv 1.00

Opening plot unit= 15
 file=ddrver1.pa0

** hspice file created for circuit decoddrver: transient&power @ 25.0c
 ***** operating point information tnom= 25.000 temp= 25.000

 ***** operating point status is voltage simulation time is 0.
 node =voltage node =voltage node =voltage

+ 0:1 = 2.0000 0:100 = 63.0000m 0:101 = 63.0000m
 + 0:102 = 63.0000m 0:104 = 31.9639m 0:105 = 720.7624m
 + 0:106 = 662.7461m 0:107 = -1.2402 0:108 = 104.5425m
 + 0:120 = 52.0502m 0:121 = 52.0502m 0:122 = 52.0502m
 + 0:130 = 9.6973u 0:150 = -1.2402 0:151 = -1.2402
 + 0:152 = -1.2402 0:153 = -1.2402 0:154 = -1.2402
 + 0:155 = -1.2402 0:156 = -1.2402 0:157 = -1.2402
 + 0:160 = 31.9780m 0:161 = 30.9568m 0:170 = -1.2402
 + 0:171 = -1.2402 0:200 = 630.0000m 0:201 = 63.0000m
 + 0:202 = 63.0000m 0:777 = -2.5000 0:888 = 2.0000
 + 1:10 = 633.6943m 1:11 = 11.3673m 1:12 = 726.7178m
 + 1:13 = 49.0605m 1:14 = 692.6305m 2:12 = 658.6414m
 + 2:13 = 658.6414m 2:14 = 658.6414m 2:15 = 53.9658m
 + 2:16 = 52.0088m 2:17 = 32.4497m 2:18 = 32.4488m
 + 2:19 = 52.0088m 2:20 = 32.4497m 2:21 = 32.4488m
 + 2:22 = 52.0088m 2:23 = 32.4497m 2:24 = 32.4488m
 + 2:25 = 17.6214u 2:26 = 17.6214u 2:27 = 17.6214u
 + 2:28 = 629.9885m 2:29 = 629.9926m 2:30 = 629.9967m
 + 2:31 = 48.9071u 2:33 = 630.0137m 3:30 = 31.9766m
 + 3:31 = 30.9553m 3:32 = 30.9553m 3:33 = 30.6021m
 + 3:34 = 30.9553m 3:35 = 30.6021m 3:36 = 30.6021m
 + 3:37 = 30.4227m 3:40 = 52.0136m 3:41 = 52.0137m
 + 3:42 = 52.0137m 3:43 = 52.0137m 3:44 = 52.0137m
 + 3:45 = 52.0137m 3:46 = 52.0137m 3:47 = 52.0137m
 + 3:48 = 652.8042m 3:50 = 31.7757m 4:8 = 1.2978
 + 5:9 = 53.4430m 6:9 = 1.3829 7:8 = 57.9851m
 + 8:9 = 1.3554 9:9 = 56.8501m 10:9 = 1.3747
 + 11:6 = 636.2190m 11:9 = 58.0085m 12:6 = 1.3578
 + 12:7 = 652.5236m 12:9 = 74.9274m 12:10 = 230.8765m
 + 12:11 = -504.6670m 12:12 = -1.5552 12:13 = -1.8701
 + 12:14 = -2.1851 12:25 = 1.9694 13:6 = -379.5736m
 + 13:7 = -1.0721 13:9 = 1.9993 13:10 = 1.5989
 + 13:11 = 851.7076m 13:12 = -546.5932m 13:13 = -1.1977
 + 13:14 = -1.8489 13:25 = 52.2021m 14:8 = 31.9352m

+ 14:9	= 692.6027m	14:10	= 10.5772m	14:11	= 10.5781m
+ 14:12	= 10.5790m	15:7	= 78.5842m	15:8	= 635.5417m
+ 15:9	= 607.4009m	15:10	= 58.7776m	16:11	= 624.0781m
+ 16:12	= 52.0115m	16:13	= 52.0127m	16:14	= 52.0115m
+ 16:15	= 52.0127m	16:16	= 32.4480m	16:17	= 52.0127m
+ 16:18	= 52.0127m	16:19	= 26.2560m	16:20	= 52.0509m
+ 16:21	= 52.0488m	16:22	= 52.0458m	16:23	= 52.0115m
+ 21:10	= 658.6317m	21:11	= 53.9637m	22:10	= 653.5035m
+ 22:11	= 653.6595m	23:10	= 52.0534m	23:11	= 653.6593m
+ 23:12	= 653.6593m	24:10	= 658.6317m	24:11	= 53.9637m
+ 25:10	= 653.5035m	25:11	= 653.6595m	26:10	= 52.0534m
+ 26:11	= 653.6593m	26:12	= 653.6593m	27:10	= 658.6317m
+ 27:11	= 53.9637m	28:10	= 653.5035m	28:11	= 653.6595m
+ 29:10	= 52.0534m	29:11	= 653.6593m	29:12	= 653.6593m
+ 30:7	= 658.5020m	31:7	= 658.5020m	32:7	= 658.5020m
+ 33:18	= 606.7231m	33:19	= 606.7231m	33:20	= 606.7231m
+ 35:9	= 690.8217m	35:10	= 19.5641m	35:11	= 690.8861m
+ 36:9	= 16.3431m	36:10	= 19.5641m	36:11	= 692.6857m
+ 37:10	= 658.7406m	37:11	= 52.2065m	38:10	= 658.7429m
+ 38:11	= 52.2065m	39:10	= 658.7429m	39:11	= 52.2065m
+ 40:10	= 658.7437m	40:11	= 52.2065m	41:10	= 658.7429m
+ 41:11	= 52.2065m	42:10	= 658.7437m	42:11	= 52.2065m
+ 43:10	= 658.7437m	43:11	= 52.2065m	44:10	= 658.7441m
+ 44:11	= 52.2065m	45:6	= 1.3554	45:7	= 650.5943m
+ 45:9	= 74.9593m	45:10	= 230.9021m	45:11	= -504.6416m
+ 45:12	= -1.5551	45:13	= -1.8701	45:14	= -2.1850
+ 45:25	= 1.9660	46:6	= 1.3554	46:7	= 650.5943m
+ 46:9	= 74.9593m	46:10	= 230.9021m	46:11	= -504.6416m
+ 46:12	= -1.5551	46:13	= -1.8701	46:14	= -2.1850
+ 46:25	= 1.9660	47:6	= 1.3554	47:7	= 650.5943m
+ 47:9	= 74.9593m	47:10	= 230.9021m	47:11	= -504.6416m
+ 47:12	= -1.5551	47:13	= -1.8701	47:14	= -2.1850
+ 47:25	= 1.9660	48:6	= 1.3554	48:7	= 650.5943m
+ 48:9	= 74.9593m	48:10	= 230.9021m	48:11	= -504.6416m
+ 48:12	= -1.5551	48:13	= -1.8701	48:14	= -2.1850
+ 48:25	= 1.9660	49:6	= 1.3554	49:7	= 650.5943m
+ 49:9	= 74.9593m	49:10	= 230.9021m	49:11	= -504.6416m
+ 49:12	= -1.5551	49:13	= -1.8701	49:14	= -2.1850
+ 49:25	= 1.9660	50:6	= 1.3554	50:7	= 650.5943m
+ 50:9	= 74.9593m	50:10	= 230.9021m	50:11	= -504.6416m
+ 50:12	= -1.5551	50:13	= -1.8701	50:14	= -2.1850
+ 50:25	= 1.9660	51:6	= 1.3554	51:7	= 650.5943m
+ 51:9	= 74.9593m	51:10	= 230.9021m	51:11	= -504.6416m
+ 51:12	= -1.5551	51:13	= -1.8701	51:14	= -2.1850
+ 51:25	= 1.9660	52:6	= 1.3554	52:7	= 650.5943m
+ 52:9	= 74.9593m	52:10	= 230.9021m	52:11	= -504.6416m
+ 52:12	= -1.5551	52:13	= -1.8701	52:14	= -2.1850
+ 52:25	= 1.9660	53:6	= 1.3578	53:7	= 652.5225m
+ 53:9	= 74.9274m	53:10	= 230.8765m	53:11	= -504.6670m
+ 53:12	= -1.5552	53:13	= -1.8701	53:14	= -2.1851
+ 53:25	= 1.9694	54:6	= 1.3579	54:7	= 652.6040m

+ 54:9	= 74.9262m	54:10	= 230.8755m	54:11	= -504.6679m
+ 54:12	= -1.5552	54:13	= -1.8701	54:14	= -2.1851
+ 54:25	= 1.9695	57:6	= 33.9796m	57:9	= 58.0085m
+ 60:9	= 1.3553	61:9	= 53.9676m	62:9	= 53.9669m
+ 63:9	= 53.9663m	64:8	= 56.8134m	65:9	= 678.3717m
+ 66:7	= 631.5538m	66:8	= 678.6259m	66:9	= 65.8780m
+ 69:7	= 622.4007m	69:8	= 652.8533m	69:9	= 652.6687m
+ 71:10	= 658.7911m	71:11	= 54.9626m	72:10	= 658.7914m
+ 72:11	= 53.9676m	73:6	= 658.5363m	74:10	= 658.7911m
+ 74:11	= 54.9626m	75:10	= 658.7914m	75:11	= 53.9676m
+ 76:10	= 653.6590m	76:11	= 53.9669m	76:12	= 653.6590m
+ 77:7	= 658.4423m	78:10	= 658.7914m	78:11	= 53.9669m
+ 79:10	= 658.7914m	79:11	= 53.9676m	80:10	= 651.6432m
+ 80:11	= 651.6432m	80:12	= 651.6432m	80:13	= 53.9663m
+ 81:10	= 54.9626m	81:11	= 658.7911m	82:8	= 658.3019m
+ 83:9	= 52.0506m	83:10	= 624.0440m	83:11	= 636.5449m
+ 83:12	= 636.5992m	84:9	= 52.0506m	84:10	= 624.0440m
+ 84:11	= 636.5449m	84:12	= 636.5992m	85:9	= 52.0506m
+ 85:10	= 624.0440m	85:11	= 636.5449m	85:12	= 636.5992m
+ 125:7	= 692.2401m	126:9	= 6.7626m	126:10	= 6.7626m
+ 126:11	= 6.7626m	126:12	= 692.6852m	127:9	= 690.8211m
+ 127:10	= 6.7626m	127:11	= 6.7626m	127:12	= 690.8856m
+ 128:9	= 6.7626m	128:10	= 690.8211m	128:11	= 6.7626m
+ 128:12	= 690.8856m	129:9	= 690.1607m	129:10	= 690.1607m
+ 129:11	= 6.7626m	129:12	= 690.2249m	130:9	= 6.7626m
+ 130:10	= 6.7626m	130:11	= 690.8211m	130:12	= 690.8856m
+ 131:9	= 690.1607m	131:10	= 6.7626m	131:11	= 690.1607m
+ 131:12	= 690.2249m	132:9	= 6.7626m	132:10	= 690.1607m
+ 132:11	= 690.1607m	132:12	= 690.2249m	133:9	= 689.8191m
+ 133:10	= 689.8191m	133:11	= 689.8191m	133:12	= 689.8833m
+ 134:9	= 1.3536	135:9	= 52.2065m	136:9	= 1.3539
+ 137:8	= 42.5789m	138:9	= 52.0282m	139:9	= 52.2065m
+ 140:9	= 1.3556	141:8	= 56.8403m	178:8	= 1.3147
+ 179:6	= 6.0274m	181:6	= 32.7632m	182:6	= 48.4090m
+ 183:6	= 36.3487m	184:6	= 58.4402m	186:6	= 8.5683m
+ 187:6	= 10.5824m	187:7	= 684.7784m	187:9	= 16.3579m
+ 188:6	= 692.7547m	188:7	= 32.0179m	188:9	= 16.3022m
+ 225:10	= 53.0867m	225:11	= 54.9689m	225:12	= 658.5204m
+ 226:10	= 651.5335m	226:11	= 651.6421m	226:12	= 651.5924m
+ 226:13	= 26.2529m	227:10	= 54.9689m	227:11	= 658.7304m
+ 227:12	= 53.0867m	227:13	= 51.9668m	228:10	= 53.0929m
+ 228:11	= 653.6561m	228:12	= 653.5469m	228:13	= 32.4387m
+ 229:10	= 54.9689m	229:11	= 53.9676m	229:12	= 640.4275m
+ 230:10	= 653.6591m	230:11	= 653.6591m	230:12	= 53.0929m
+ 230:13	= 32.4484m	231:10	= 53.0867m	231:11	= 54.9689m
+ 231:12	= 658.5204m	232:10	= 651.5335m	232:11	= 651.6421m
+ 232:12	= 651.5924m	232:13	= 26.2529m	233:10	= 54.9689m
+ 233:11	= 658.7304m	233:12	= 53.0867m	233:13	= 51.9668m
+ 234:10	= 53.0929m	234:11	= 653.6561m	234:12	= 653.5469m
+ 234:13	= 32.4387m	235:10	= 54.9689m	235:11	= 53.9669m
+ 235:12	= 640.4275m	236:10	= 653.6591m	236:11	= 653.6591m

+236:12	= 53.0929m	236:13	= 32.4484m	237:10	= 53.0867m
+237:11	= 54.9689m	237:12	= 658.5204m	238:10	= 651.5335m
+238:11	= 651.6421m	238:12	= 651.5924m	238:13	= 26.2529m
+239:10	= 54.9689m	239:11	= 658.7304m	239:12	= 53.0867m
+239:13	= 51.9668m	240:10	= 53.0929m	240:11	= 653.6561m
+240:12	= 653.5469m	240:13	= 32.4387m	241:10	= 54.9689m
+241:11	= 53.9663m	241:12	= 640.4275m	242:10	= 653.6591m
+242:11	= 653.6591m	242:12	= 53.0929m	242:13	= 32.4484m
+243:8	= 1.3540	244:9	= 56.7487m	245:9	= 58.9632m
+246:9	= 58.9632m	247:9	= 58.9632m	248:9	= 1.3556
+249:8	= 56.8380m	250:9	= 1.3536	251:9	= 58.9632m
+252:9	= 58.9632m	253:9	= 1.3539	254:8	= 42.5769m
+255:9	= 58.9632m	256:9	= 1.3536	257:9	= 58.9632m
+258:9	= 1.3539	259:8	= 42.5769m	260:9	= 1.3530
+261:9	= 1.3530	262:9	= 58.9632m	263:9	= 1.3532
+264:8	= 38.1889m	265:9	= 58.9632m	266:9	= 58.9632m
+267:9	= 1.3536	268:9	= 1.3539	269:8	= 42.5769m
+270:9	= 1.3530	271:9	= 58.9632m	272:9	= 1.3530
+273:9	= 1.3532	274:8	= 38.1889m	275:9	= 58.9632m
+276:9	= 1.3530	277:9	= 1.3530	278:9	= 1.3532
+279:8	= 38.1889m	280:9	= 1.3527	281:9	= 1.3527
+282:9	= 1.3527	283:9	= 1.3529	284:8	= 36.0549m
+285:9	= 52.0275m	286:9	= 53.9637m	287:8	= 1.3479
+288:9	= 55.0192m	289:9	= 52.0302m	290:9	= 1.3559
+291:8	= 56.8710m	292:9	= 1.2949		

Opening plot unit= 16
 file=ddrver1.tr0

```
** hspice file created for circuit decoddrver: transient&power @ 25.0c
***** transient analysis          tnom= 25.000 temp= 25.000
*****
avgpwr      = -2.7061E-01 from= 0.0000E+00  to= 8.7000E-08
vmax        = 5.9400E-01 at= 6.4802E-08
            from= 2.0000E-09 to= 8.8000E-08
vmin        = 5.0752E-02 at= 7.2991E-08
            from= 2.0000E-09 to= 8.8000E-08
tphl        = 1.2805E-09 targ= 1.4637E-08 trig= 1.3357E-08
tplh        = 1.0183E-09 targ= 1.4375E-08 trig= 1.3357E-08
trise       = 5.0463E-10 targ= 1.4790E-08 trig= 1.4286E-08
tfall       = 2.3630E-10 targ= 1.4761E-08 trig= 1.4525E-08
tdelay      = 1.2808E-09 targ= 1.4632E-08 trig= 1.3352E-08
```

```
***** job concluded
total cpu time   4629.20 seconds
job started at 18:44:12 4-feb93
job ended at 21:25:37 4-feb93
```

I am done with ddriver1.sp
Thu Feb 4 21:25:39 PST 1993

O. Listing File for OUTPUT Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)

```
***** hspice 9007d 12:44:56 5-feb93 sun
** hspice file created for circuit output: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
* hspice dcfl 2-input nor subcircuit
*      ina, inb, output, power, ground
.subckt d2nor 1 2 3 4 5
* d g s b
j0 4 3 3 5 jfet16 l=1.2 w=6.0
j1 3 1 5 5 jfet04 l=1.2 w=96.0
j2 3 2 5 5 jfet04 l=1.2 w=96.0
.ends d2nor
*****
* hspice dcfl 2-input demorgan and subcircuit
*      ina, inb, output, power, ground
.subckt dd2and 1 2 3 4 5
x0 1 10 4 5 dinv
x1 2 11 4 5 dinv
x2 10 11 3 4 5 d2nor
.ends dd2and
*****
* subcircuit dcfl 2-input or
*      ina inb output power ground
```

```

.subckt dd2or 1 2 3 4 5
* ina inb out pwr gnd subname
x0 1 2 6 4 5 d2nor
x1 6 3 4 5 dinv
.ends dd2or
*****
*****  

* hspice dcfl 2-input real nand subcircuit
*      ina, inb, output, power, ground
.subckt d2nand 1 2 3 4 5
* d g s b
j0 4 3 3 5 jfet16 l=1.2 w=6.0
j1 3 1 6 5 jfet04 l=1.2 w=192.0
j2 6 2 5 5 jfet04 l=1.2 w=192.0
.ends d2nand
*****
*****  

* subcircuit dcfl 4-input or
*      ina inb inc ind output power ground
.subckt dd4or 1 2 3 4 5 6 7
* ina inb inc ind out pwr gnd subname
x0 1 2 3 4 8 6 7 d4nor
x1 8 5 6 7 dinv
.ends dd4or
*****
*****  

* hspice dcfl 4-input nor subcircuit
*      ina, inb, inc, ind, output, power, ground
.subckt d4nor 1 2 3 4 5 6 7
* d g s b
j0 6 5 5 7 jfet16 l=1.2 w=6.0
j1 5 1 7 7 jfet04 l=1.2 w=96.0
j2 5 2 7 7 jfet04 l=1.2 w=96.0
j3 5 3 7 7 jfet04 l=1.2 w=96.0
j4 5 4 7 7 jfet04 l=1.2 w=96.0
.ends d4nor
*****
*****  

* hspice dcfl 4-input demorgan and subcircuit
*      ina, inb, inc, ind, output, power, ground
.subckt dd4and 1 2 3 4 5 6 7
x0 1 10 6 7 dinv
x1 2 11 6 7 dinv
x2 3 12 6 7 dinv
x3 4 13 6 7 dinv
x4 10 11 12 13 5 6 7 d4nor
.ends dd4and
*****
*****  

* subcircuit dcfl d-latch using generic gates
*      d clk q /q power ground

```

```

.subckt dlatch 1 2 3 4 5 6
* ina inb output power ground subname
x0 1 2 8 5 6 d2nand
x1 1 7 5 6 dinv
x2 2 7 9 5 6 d2nand
x3 8 4 3 5 6 d2nand
x4 9 3 4 5 6 d2nand
.ends dlatch
*****
*****  

* subcircuit output
* oddbio evenbio edummy odummy rd q /q pwr gnd
.subckt output 1 2 3 4 5 6 7 8 9
* ina inb inc ind ine inf
x0 1 12 8 9 dinv
x1 2 13 8 9 dinv
x2 3 14 8 9 dinv
x3 4 15 8 9 dinv
x4 1 4 13 14 17 8 9 dd4and
x5 12 15 2 3 30 8 9 dd4and
x6 1 15 2 3 31 8 9 dd4and
x7 1 4 2 14 20 8 9 dd4and
x8 17 30 31 20 21 8 9 dd4or
x9 3 4 22 8 9 dd2or
x10 5 22 16 8 9 dd2and
x11 21 16 6 7 8 9 dlatch
.ends output
*****
*****  

* hspice dcfl standard load subcircuit
* input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card
*.temp 85.0

* signal inputs

* next three lines used to provide test signal inputs for transient analysis
vodbio 100 0 pulse(0.63 0.063 8400ps 100ps 100ps 8200ps 16800ps)
vevenbio 101 0 pulse(0.063 0.63 8400ps 100ps 100ps 8200ps 16800ps)

```

```

vdummy 102 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vodummy 103 0 pulse(0.63 0.063 4200ps 100ps 100ps 4000ps 8400ps)
vread 104 0 pulse(0.063 0.63 16800ps 100ps 100ps 16600ps 33600ps)

```

* main circuit

```

x0 100 101 102 103 104 110 111 1 0 output $ element under test
x1 110 120 888 0 d2load $ test load
x2 111 121 888 0 d2load $ test load

```

```
.ic v(110)=0.063 v(111)=0.63
```

* measurement parameters

* next two lines are used for transient analysis

```

.probe oddbio=v(100) evenbio=v(101) edummy=v(102)
+ odummy=v(103) mread=v(104) dox=v(110) /dox=v(111)
.probe tran p(vds) p(vload) power
.measure tran avgpwr avg p(vds)

```

* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis

```

.meas tran vmax max v(110) from=2ns to=35ns
.meas tran vmin min v(110) from=2ns to=35ns
.meas tran tphl trig v(103) val='(vmax-vmin)*.5' td=20ns
+ fall=1 targ v(110) val='(vmax-vmin)*.5' td=20ns fall=1
.meas tran tplh trig v(104) val='(vmax-vmin)*.5' td=2ns
+ rise=1 targ v(110) val='(vmax-vmin)*.5' td=15ns rise=1
.meas tran trise trig v(110) val='vmin+0.1*vmax' td=15ns
+ rise=1 targ v(110) val='0.9*vmax' rise=1
.meas tran tfall trig v(110) val='0.9*vmax' td=20ns
+ fall=1 targ v(110) val='vmin+0.1*vmax' fall=1
.meas tran tdelay trig v(104) val=.2835 td=15ns rise=1
+ targ v(110) val=.2835 td=15ns rise=1
.tran 500ps 35ns

```

```
.options scale=1e-06 brief=0 nopage measout post probe
```

```
.end
```

** hspice file created for circuit output: transient&power @ 25.0c

***** circuit name directory

circuit number to circuit name directory

number	circuitname	definition	multiplier
--------	-------------	------------	------------

0 main circuit

1 x0.	output	1.00
2 x1.	d2load	1.00
3 x2.	d2load	1.00
4 x0.x0.	dinv	1.00
5 x0.x1.	dinv	1.00
6 x0.x2.	dinv	1.00
7 x0.x3.	dinv	1.00
8 x0.x4.	dd4and	1.00
9 x0.x5.	dd4and	1.00
10 x0.x6.	dd4and	1.00
11 x0.x7.	dd4and	1.00

12 x0.x8.	dd4or	1.00
13 x0.x9.	dd2or	1.00
14 x0.x10.	dd2and	1.00
15 x0.x11.	dlatch	1.00
16 x1.x0.	dinv	1.00
17 x1.x1.	dinv	1.00
18 x2.x0.	dinv	1.00
19 x2.x1.	dinv	1.00
20 x0.x4.x0.	dinv	1.00
21 x0.x4.x1.	dinv	1.00
22 x0.x4.x2.	dinv	1.00
23 x0.x4.x3.	dinv	1.00
24 x0.x4.x4.	d4nor	1.00
25 x0.x5.x0.	dinv	1.00
26 x0.x5.x1.	dinv	1.00
27 x0.x5.x2.	dinv	1.00
28 x0.x5.x3.	dinv	1.00
29 x0.x5.x4.	d4nor	1.00
30 x0.x6.x0.	dinv	1.00
31 x0.x6.x1.	dinv	1.00
32 x0.x6.x2.	dinv	1.00
33 x0.x6.x3.	dinv	1.00
34 x0.x6.x4.	d4nor	1.00
35 x0.x7.x0.	dinv	1.00
36 x0.x7.x1.	dinv	1.00
37 x0.x7.x2.	dinv	1.00
38 x0.x7.x3.	dinv	1.00
39 x0.x7.x4.	d4nor	1.00
40 x0.x8.x0.	d4nor	1.00
41 x0.x8.x1.	dinv	1.00
42 x0.x9.x0.	d2nor	1.00
43 x0.x9.x1.	dinv	1.00
44 x0.x10.x0.	dinv	1.00
45 x0.x10.x1.	dinv	1.00
46 x0.x10.x2.	d2nor	1.00
47 x0.x11.x0.	d2nand	1.00
48 x0.x11.x1.	dinv	1.00
49 x0.x11.x2.	d2nand	1.00
50 x0.x11.x3.	d2nand	1.00
51 x0.x11.x4.	d2nand	1.00

Opening plot unit= 15

file=output1.pa0

** hspice file created for circuit output: transient&power @ 25.0c
***** operating point information tnom= 25.000 temp= 25.000

***** operating point status is voltage simulation time is 0.
node =voltage node =voltage node =voltage

+ 0:1 = 2.0000 0:100 = 630.0000m 0:101 = 63.0000m

```

+ 0:102 = 63.0000m 0:103 = 630.0000m 0:104 = 63.0000m
+ 0:110 = 63.0042m 0:111 = 630.0010m 0:120 = 1.9844
+ 0:121 = 53.9657m 0:888 = 2.0000 1:12 = 53.9658m
+ 1:13 = 658.6414m 1:14 = 636.5005m 1:15 = 53.9658m
+ 1:16 = 52.0112m 1:17 = 658.1907m 1:20 = 51.9209m
+ 1:21 = 658.6896m 1:22 = 658.6821m 1:30 = 23.1807m
+ 1:31 = 26.2239m 2:5 = 1.9844 3:5 = 53.9657m
+ 8:10 = 53.9658m 8:11 = 53.9658m 8:12 = 52.0534m
+ 8:13 = 53.0980m 9:10 = 650.4496m 9:11 = 650.4496m
+ 9:12 = 650.4105m 9:13 = 650.4105m 10:10 = 53.9658m
+10:11 = 651.5163m 10:12 = 651.4771m 10:13 = 651.4771m
+11:10 = 53.9658m 11:11 = 53.9658m 11:12 = 658.6124m
+11:13 = 53.0980m 12:8 = 51.9626m 13:6 = 53.8908m
+14:10 = 658.6322m 14:11 = 52.0544m 15:7 = 52.0545m
+15:8 = 668.0491m 15:9 = 1.2457 47:6 = 532.3943m
+49:6 = 75.0262m 50:6 = 40.4805m 51:6 = 638.8192m

```

Opening plot unit= 16
file=output1.tr0

```

** hspice file created for circuit output: transient&power @ 25.0c
***** transient analysis      tnom= 25.000 temp= 25.000
*****
avgpwr    = -8.1584E-02 from= 0.0000E+00 to= 3.5000E-08
vmax      = 6.3253E-01 at= 3.5000E-08
          from= 2.0000E-09 to= 3.5000E-08
vmin      = 3.9594E-02 at= 1.7238E-08
          from= 2.0000E-09 to= 3.5000E-08
tphl      = 1.0443E-09 targ= 2.2103E-08 trig= 2.1059E-08
tplh      = 5.8453E-10 targ= 1.7426E-08 trig= 1.6841E-08
trise     = 5.4070E-10 targ= 1.7847E-08 trig= 1.7307E-08
tfall     = 3.8850E-10 targ= 2.2263E-08 trig= 2.1875E-08
tdelay    = 5.7533E-10 targ= 1.7414E-08 trig= 1.6839E-08

***** job concluded
total cpu time   66.75 seconds
job started at 12:44:56 5-feb93
job ended at 12:48:21 5-feb93

```

I am done with output1.sp
Fri Feb 5 12:48:23 PST 1993

P. Listing File for WRITEP Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg

setting user memory from environment var to 250000 words. (2000000 bytes)

```
***** hspice 9007d 14:6:57 7-feb93 sun
** hspice file created for circuit writep: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
***** subcircuit operation priority circuit
*the call 14 60 61 17 18 1 0 writep
***** mref write read mwrite mread power ground
.subckt writep 1 2 3 4 5 6 7
* write priority logic 04 august 1992
x0 1 8 6 7 dinv
x1 2 9 6 7 dinv
x2 2 8 4 6 7 dd2and
x3 3 9 8 5 6 7 dd3and
.ends writep
*****
***** hspice dcfl 2-input demorgan and subcircuit
* ina, inb, output, power, ground
.subckt dd2and 1 2 3 4 5
x0 1 10 4 5 dinv
x1 2 11 4 5 dinv
x2 10 11 3 4 5 d2nor
.ends dd2and
*****
***** hspice dcfl 2-input nor subcircuit
* ina, inb, output, power, ground
.subckt d2nor 1 2 3 4 5
* d g s b
j0 4 3 3 5 jfet16 l=1.2 w=6.0
j1 3 1 5 5 jfet04 l=1.2 w=96.0
j2 3 2 5 5 jfet04 l=1.2 w=96.0
.ends d2nor
*****
***** hspice dcfl inverter subcircuit
* input, output, power, ground
.subckt dinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
```

```

*****
* hspice dcfl 3-input nor subcircuit
*      ina, inb, inc, output, power, ground
.subckt d3nor  1 2 3 4 5 6
* d g s b
j0 5 4 4 6 jfet16 l=1.2 w=6.0
j1 4 1 6 6 jfet04 l=1.2 w=96.0
j2 4 2 6 6 jfet04 l=1.2 w=96.0
j3 4 3 6 6 jfet04 l=1.2 w=96.0
.ends d3nor
*****
*****
* hspice dcfl 3-input demorgan and subcircuit
*      ina, inb, inc, output, power, ground
.subckt dd3and 1 2 3 4 5 6
x0 1 10 5 6 dinv
x1 2 11 5 6 dinv
x2 3 12 5 6 dinv
x3 10 11 12 4 5 6 d3nor
.ends dd3and
*****
*****
* hspice dcfl standard load subcircuit
*      input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card
*.temp 85.0

* signal inputs

* next three lines used to provide test signal inputs for transient analysis
vread 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vwwrite 101 0 pulse(0.063 0.63 8400ps 100ps 100ps 8200ps 16800ps)
vmrefresh 102 0 pulse(0.063 0.63 16800ps 100ps 100ps 16600ps 33600ps)

* main circuit
x0 102 101 100 104 103 1 0 writep $ element under test
x1 103 107 888 0 d2load $ test load
x2 104 108 888 0 d2load $ test load

```

* measurement parameters

* next two lines are used for transient analysis
.probe read=v(100) write=v(101) mrefresh=v(102) mread=v(103)
+ mwrit=v(104)
.probe tran p(vds) p(vload) power

.measure tran avgpwr avg p(vds)
* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis
.meas tran vmax max v(103) from=2ns to=42ns
.meas tran vmin min v(103) from=2ns to=42ns
.meas tran tphi trig v(100) val='(vmax-vmin)*.5' td=2ns
+ fall=1 targ v(103) val='(vmax-vmin)*.5' td=2ns fall=1
.meas tran tphi trig v(100) val='(vmax-vmin)*.5' td=2ns
+ rise=1 targ v(103) val='(vmax-vmin)*.5' td=2ns rise=1
.meas tran trise trig v(103) val='vmin+0.1*vmax' td=2ns
+ rise=1 targ v(103) val='0.9*vmax' rise=1
.meas tran tfall trig v(103) val='0.9*vmax' td=2ns
+ fall=1 targ v(103) val='vmin+0.1*vmax' fall=1
.meas tran tdelay trig v(100) val=.2835 td=2ns rise=1
+ targ v(103) val=.2835 rise=1
.tran 100ps 42ns
.options scale=1e-06 brief=0 nopage measout post probe
.end

** hspice file created for circuit writep: transient&power @ 25.0c

***** circuit name directory

circuit number to circuit name directory

number	circuitname	definition	multiplier
--------	-------------	------------	------------

0 main circuit

1 x0.	writep	1.00
2 x1.	d2load	1.00
3 x2.	d2load	1.00
4 x0.x0.	dinv	1.00
5 x0.x1.	dinv	1.00
6 x0.x2.	dd2and	1.00
7 x0.x3.	dd3and	1.00
8 x1.x0.	dinv	1.00
9 x1.x1.	dinv	1.00
10 x2.x0.	dinv	1.00
11 x2.x1.	dinv	1.00
12 x0.x2.x0.	dinv	1.00
13 x0.x2.x1.	dinv	1.00
14 x0.x2.x2.	d2nor	1.00
15 x0.x3.x0.	dinv	1.00
16 x0.x3.x1.	dinv	1.00
17 x0.x3.x2.	dinv	1.00
18 x0.x3.x3.	d3nor	1.00

Opening plot unit= 15

```

file=writep1.pa0

** hspice file created for circuit writep: transient&power @ 25.0c
***** operating point information tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is 0.
node =voltage node =voltage node =voltage

+0:1   = 2.0000 0:100 = 63.0000m 0:101 = 63.0000m
+0:102 = 63.0000m 0:103 = 51.9677m 0:104 = 52.0099m
+0:107 = 1.9872 0:108 = 1.9872 0:888 = 2.0000
+1:8   = 636.5005m 1:9   = 658.6414m 2:5   = 1.9872
+3:5   = 1.9872 6:10 = 658.6319m 6:11 = 53.0980m
+7:10  = 658.6227m 7:11 = 52.0534m 7:12 = 53.0980m

```

Opening plot unit= 16

file=writep1.tr0

```

** hspice file created for circuit writep: transient&power @ 25.0c
***** transient analysis tnom= 25.000 temp= 25.000
*****
avgpwr    = -2.0557E-02 from= 0.0000E+00 to= 4.2000E-08
vmax      = 6.3760E-01 at= 3.8350E-08
from= 2.0000E-09 to= 4.2000E-08
vmin      = 2.0039E-02 at= 3.3675E-08
from= 2.0000E-09 to= 4.2000E-08
tphl      = 1.2793E-10 targ= 8.4846E-09 trig= 8.3567E-09
tplh      = 1.4321E-10 targ= 4.3866E-09 trig= 4.2433E-09
trise     = 3.9394E-10 targ= 4.6674E-09 trig= 4.2735E-09
tfall     = 1.6279E-10 targ= 8.5831E-09 trig= 8.4203E-09
tdelay    = 1.3022E-10 targ= 4.3691E-09 trig= 4.2389E-09

***** job concluded
total cpu time 25.91 seconds
job started at 14: 6:57 7-feb93
job ended at 14: 8:23 7-feb93

```

I am done with writep1.sp
Sun Feb 7 14:08:24 PST 1993

Q. Listing File for MBSY Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)

```

***** h s p i c e 9007d 20:45:58 7-feb93 sun
** hspice file created for circuit mbsy: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv 1 2 3 4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
*****
* hspice dcfl 3-input nor subcircuit
*      ina, inb, inc, output, power, ground
.subckt d3nor 1 2 3 4 5 6
* d g s b
j0 5 4 4 6 jfet16 l=1.2 w=6.0
j1 4 1 6 6 jfet04 l=1.2 w=96.0
j2 4 2 6 6 jfet04 l=1.2 w=96.0
j3 4 3 6 6 jfet04 l=1.2 w=96.0
.ends d3nor
*****
*****
* subcircuit dcfl 3-input or
*      ina inb inc output power ground
.subckt dd3or 1 2 3 4 5 6
* ina inb inc out pwr gad subname
x0 1 2 3 7 5 6 d3nor
x1 7 4 5 6 dinv
.ends dd3or
*****
*****
* hspice dcfl standard load subcircuit
*      input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies

```

```

vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card
*.temp 85.0

* signal inputs

* next three lines used to provide test signal inputs for transient analysis
vmread 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vmwrite 101 0 pulse(0.063 0.63 8400ps 100ps 100ps 8200ps 16800ps)
vmrefresh 102 0 pulse(0.063 0.63 16800ps 100ps 100ps 16600ps 33600ps)

* main circuit
x0 100 101 102 103 1 0 dd3or $ element under test
x1 103      107 888 0 d2load $ test load
x2 104      108 888 0 d2load $ test load

* measurement parameters

* next two lines are used for transient analysis
.probe mread=v(100) mwrite=v(101) mrefresh=v(102) mbsy=v(103)
.probe tran p(vds) p(vload) power

.measure tran avgpwr avg p(vds)
* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis
.meas tran vmax max v(103) from=2ns to=42ns
.meas tran vmin min v(103) from=2ns to=42ns
.meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=32ns
+ fall=1 targ v(103) val='(vmax-vmin)*.5' td=32ns fall=1
.meas tran tphh trig v(100) val='(vmax-vmin)*.5' td=2ns
+ rise=1 targ v(103) val='(vmax-vmin)*.5' td=2ns rise=1
.meas tran trise trig v(103) val='vmin+0.1*vmax' td=2ns
+ rise=1 targ v(103) val='0.9*vmax' rise=1
.meas tran tfall trig v(103) val='0.9*vmax' td=32ns
+ fall=1 targ v(103) val='vmin+0.1*vmax' fall=1
.meas tran tdelay trig v(100) val=.2835 td=2ns rise=1
+ targ v(103) val=.2835 rise=1
.tran 100ps 42ns
.options scale=1e-06 brief=0 nopage measout post probe
.end
** hspice file created for circuit mbsy: transient&power @ 25.0c
***** circuit name directory
*****
circuit number to circuit name directory
number circuitname           definition multiplier
 0 main circuit
 1 x0.          dd3or     1.00
 2 x1.          d2load    1.00

```

3 x2.	d2load	1.00
4 x0.x0.	d3nor	1.00
5 x0.x1.	dinv	1.00
6 x1.x0.	dinv	1.00
7 x1.x1.	dinv	1.00
8 x2.x0.	dinv	1.00
9 x2.x1.	dinv	1.00

Opening plot unit= 15
file=mbsy1.pa0

** hspice file created for circuit mbsy: transient&power @ 25.0c
***** operating point information tnom= 25.000 temp= 25.000

***** operating point status is voltage simulation time is 0.
node =voltage node =voltage node =voltage

+0:1 = 2.0000 0:100 = 63.0000m 0:101 = 63.0000m
+0:102 = 63.0000m 0:103 = 52.0444m 0:104 = 46.8784m
+0:107 = 1.9872 0:108 = 1.9883 0:888 = 2.0000
+1:7 = 658.2372m 2:5 = 1.9872 3:5 = 1.9883

Opening plot unit= 16
file=mbsy1.tr0

** hspice file created for circuit mbsy: transient&power @ 25.0c
***** transient analysis tnom= 25.000 temp= 25.000

avgpwr = -4.5233E-03 from= 0.0000E+00 to= 4.2000E-08
vmax = 6.4100E-01 at= 3.3625E-08
from= 2.0000E-09 to= 4.2000E-08
vmin = 5.1475E-02 at= 3.4125E-08
from= 2.0000E-09 to= 4.2000E-08
tphl = 2.2152E-10 targ= 3.3781E-08 trig= 3.3559E-08
tplh = 1.1997E-10 targ= 4.3608E-09 trig= 4.2409E-09
trise = 3.4966E-10 targ= 4.6355E-09 trig= 4.2859E-09
tfall = 1.3832E-10 targ= 3.3841E-08 trig= 3.3703E-08
tdelay = 1.1568E-10 targ= 4.3546E-09 trig= 4.2389E-09

***** job concluded
total cpu time 16.16 seconds
job started at 20:45:58 7-feb93
job ended at 20:46:48 7-feb93

I am done with mbsy1.sp
Sun Feb 7 20:46:50 PST 1993

R. Listing File for DRDY Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)

```
***** h s p i c e  9007d      5:51:54  8-feb93  sun
** hspice file created for circuit drdy: transient&power @ 25.0c
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
** standard 16-to-1 ratio of pull-down-to-pullup is used
*****
* hspice dcfl 2-input demorgan and subcircuit
*      ina, inb, output, power, ground
.subckt dd2and  1  2  3  4  5
x0 1  10 4 5 dinv
x1 2  11 4 5 dinv
x2 10 11 3 4 5 d2nor
.ends dd2and
*****
* hspice dcfl 2-input nor subcircuit
*      ina, inb, output, power, ground
.subckt d2nor   1  2  3  4  5
* d g s b
j0 4 3 3 5 jfet16 l=1.2 w=6.0
j1 3 1 5 5 jfet04 l=1.2 w=96.0
j2 3 2 5 5 jfet04 l=1.2 w=96.0
.ends d2nor
*****
* subcircuit dcfl 2-input or
*      ina  inb  output power ground
.subckt dd2or   1  2  3  4  5
* ina inb out pwr gnd subname
x0 1  2  6  4  5 d2nor
x1 6   3  4  5 dinv
.ends dd2or
*****
* hspice dcfl inverter subcircuit
*      input, output, power, ground
.subckt dinv   1  2  3  4
* d g s b
j0 3 2 2 4 jfet16 l=1.2 w=6.0
```

```

j1 2 1 4 4 jfet04 l=1.2 w=96.0
.ends dinv
*****
* hspice dcfl standard load subcircuit
*      input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card
*.temp 85.0

* signal inputs

* next three lines used to provide test signal inputs for transient analysis
vread 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vedum 101 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vodum 102 0 pulse(0.63 0.063 4200ps 100ps 100ps 4000ps 8400ps)

* main circuit
*****
* data ready (drdy) circuit
x0 101 102 104 1 0 dd2or $ element under test
x1 104 100 105 1 0 dd2and $ element under test
x2 105 103 1 0 dinv $ element under test
*****
x3 103 107 888 0 d2load $ test load

* measurement parameters

* next two lines are used for transient analysis
.probe mread=v(100) edum=v(101) odum=v(102) drdy=v(103)
.probe tran p(vds) p(vload) power

.measure tran avgpwr avg p(vds)
* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis
.meas tran vmax max v(103) from=2ns to=42ns
.meas tran vmin min v(103) from=2ns to=42ns
.meas tran tphl trig v(100) val='(vmax-vmin)*.5' td=2ns
+ rise=1 targ v(103) val='(vmax-vmin)*.5' td=2ns fall=1

```

```

.meas tran tpls trig v(100) val='(vmax-vmin)*.5' td=2ns
+ fall=1 targ v(103) val='(vmax-vmin)*.5' td=2ns rise=1
.meas tran trise trig v(103) val='vmin+0.1*vmax' td=2ns
+ rise=1 targ v(103) val='0.9*vmax' rise=1
.meas tran tfall trig v(103) val='0.9*vmax' td=2ns
+ fall=2 targ v(103) val='vmin+0.1*vmax' fall=2
.meas tran tdelay trig v(100) val=.2835 td=2ns fall=1
+ targ v(103) val=.2835 rise=1
.tran 100ps 42ns
.options scale=1e-06 brief=0 nopage measout post probe
.end
** hspice file created for circuit drdy: transient&power @ 25.0c
***** circuit name directory
*****

```

circuit number to circuit name directory
 number circuitname definition multiplier

0 main circuit			
1 x0.	dd2or	1.00	
2 x1.	dd2and	1.00	
3 x2.	dinv	1.00	
4 x3.	d2load	1.00	
5 x0.x0.	d2nor	1.00	
6 x0.x1.	dinv	1.00	
7 x1.x0.	dinv	1.00	
8 x1.x1.	dinv	1.00	
9 x1.x2.	d2nor	1.00	
10 x3.x0.	dinv	1.00	
11 x3.x1.	dinv	1.00	

Opening plot unit= 15
 file=drdy1.pa0

```

** hspice file created for circuit drdy: transient&power @ 25.0c
***** operating point information  tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is 0.
  node =voltage  node =voltage  node =voltage

```

```

+ 0:1    = 2.0000 0:100    = 63.0000m 0:101    = 63.0000m
+ 0:102   = 630.0000m 0:103    = 636.5447m 0:104    = 658.6821m
+ 0:105   = 52.0112m 0:107    = 53.0930m 0:888    = 2.0000
+ 1:6     = 53.8908m 2:10    = 52.0544m 2:11    = 658.6322m
+ 4:5     = 53.0930m

```

Opening plot unit= 16
 file=drdy1.tr0

```

** hspice file created for circuit drdy: transient&power @ 25.0c
***** transient analysis      tnom= 25.000 temp= 25.000

```

```
*****  
avgpwr = -1.3732E-02 from= 0.0000E+00 to= 4.2000E-08  
vmax = 6.4321E-01 at= 1.7342E-08  
from= 2.0000E-09 to= 4.2000E-08  
vmin = 5.0553E-02 at= 4.7000E-09  
from= 2.0000E-09 to= 4.2000E-08  
tphl = 2.0124E-10 targ= 4.4424E-09 trig= 4.2412E-09  
tplh = 1.7905E-10 targ= 8.5379E-09 trig= 8.3588E-09  
trise = 3.5592E-10 targ= 8.8165E-09 trig= 8.4606E-09  
tfall = 1.3901E-10 targ= 1.2913E-08 trig= 1.2774E-08  
tdelay = 1.7104E-10 targ= 8.5321E-09 trig= 8.3611E-09
```

```
***** job concluded  
total cpu time 20.37 seconds  
job started at 5:51:54 8-feb93  
job ended at 5:52:57 8-feb93
```

I am done with drdy1.sp
Mon Feb 8 05:52:59 PST 1993

S. Listing File for WLOGIC Transient Analysis @ 25.0C

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
setting user memory from environment var to 250000 words. (2000000 bytes)

```
***** hspice 9007d 9:45:34 8-feb93 sun  
** hspice file created for circuit wlogic: transient&power @ 25.0c  
***** copyright 1990 meta-software,inc. *****site:  
***** input listing  
*****  
* hspice.ini  
** technology: edgaas  
** standard 16-to-1 ratio of pull-down-to-pullup is used  
*****  
*****  
* hspice dcfl inverter subcircuit  
* input, output, power, ground  
.subckt dinv 1 2 3 4  
* d g s b  
j0 3 2 2 4 jfet16 l=1.2 w=6.0  
j1 2 1 4 4 jfet04 l=1.2 w=96.0  
.ends dinv  
*****  
*****  
* hspice dcfl 4-input nor subcircuit  
* ina, inb, inc, ind, output, power, ground  
.subckt d4nor 1 2 3 4 5 6 7
```

```

* d g s b
j0 6 5 5 7 jfet16 l=1.2 w=6.0
j1 5 1 7 7 jfet04 l=1.2 w=96.0
j2 5 2 7 7 jfet04 l=1.2 w=96.0
j3 5 3 7 7 jfet04 l=1.2 w=96.0
j4 5 4 7 7 jfet04 l=1.2 w=96.0
.ends d4nor
*****
***** hspice dcfl 4-input demorgan and subcircuit
*      ina, inb, inc, ind, output, power, ground
.subckt dd4and 1 2 3 4 5 6 7
x0 1    10 6 7 dinv
x1 2    11 6 7 dinv
x2 3    12 6 7 dinv
x3 4    13 6 7 dinv
x4 10 11 12 13 5 6 7 d4nor
.ends dd4and
*****
***** hspice dcfl 2-input real nand subcircuit
*      ina, inb, output, power, ground
.subckt d2nand 1 2 3 4 5
* d g s b
j0 4 3 3 5 jfet16 l=1.2 w=6.0
j1 3 1 6 5 jfet04 l=1.2 w=192.0
j2 6 2 5 5 jfet04 l=1.2 w=192.0
.ends d2nand
*****
***** subcircuit dcfl d-latch using generic gates
*      d clk q /q power ground
.subckt dlatch 1 2 3 4 5 6
* ina inb output power ground subname
x0 1 2 8 5 6 d2nand
x1 1 7 5 6 dinv
x2 2 7 9 5 6 d2nand
x3 8 4 3 5 6 d2nand
x4 9 3 4 5 6 d2nand
.ends dlatch
*****
***** hspice d mesfet load subcircuit
*      input, power, ground
.subckt dm10load 1 3 4
j0 3 1 4 4 jfet16 l=1.2 w= 10.0
j1 3 1 4 4 jfet16 l=1.2 w= 10.0
j2 3 1 4 4 jfet16 l=1.2 w= 10.0
j3 3 1 4 4 jfet16 l=1.2 w= 10.0
j4 3 1 4 4 jfet16 l=1.2 w= 10.0
j5 3 1 4 4 jfet16 l=1.2 w= 10.0

```

```

j6 3 1 4 4 jfet16 l=1.2 w= 10.0
j7 3 1 4 4 jfet16 l=1.2 w= 10.0
j8 3 1 4 4 jfet16 l=1.2 w= 10.0
j9 3 1 4 4 jfet16 l=1.2 w= 10.0
.ends dm10load
*****
*****
* hspice d mesfet load subcircuit
*      input, power, ground
.subckt dm4load 1 3 4
j0 3 1 4 4 jfet16 l=1.2 w= 10.0
j1 3 1 4 4 jfet16 l=1.2 w= 10.0
j2 3 1 4 4 jfet16 l=1.2 w= 10.0
j3 3 1 4 4 jfet16 l=1.2 w= 10.0
.ends dm4load
*****
*****
* subcircuit level-shifter to drive dfets
* use hspice diode models for backconnected mesfets
*      input output vds vss
.subckt lvl 1 2 3 4
* d g s b
x0 1 25 3 0 dinv
j1 3 25 6 4 jfet04 l=1.2 w=20.0
j2 7 6 7 4 dio16 l=1.2 w=4.0
j3 7 4 4 4 jfet20 l=3.0 w=3.0
j4 3 9 9 4 jfet16 l=1.2 w=3.0
j5 9 7 0 4 jfet16 l=1.2 w=10.0
j6 3 9 10 4 jfet16 l=1.2 w=20.0
j7 11 10 11 4 dio16 l=1.2 w=20.0
j8 2 11 2 4 dio16 l=1.2 w=20.0
j9 2 4 4 4 jfet16 l=1.2 w=12.0
j10 12 2 12 4 dio16 l=1.2 w=10.0
j11 13 12 13 4 dio16 l=1.2 w=10.0
j12 14 13 14 4 dio16 l=1.2 w=10.0
j13 4 14 4 4 dio16 l=1.2 w=10.0
.ends lvl
*****
*****
* subcircuit write logic in hspice
* epu=even pull up -- bring in a0 for even/odd & writing
*      data das a0 w clk epu opu opd power grnd vss
.subckt wlogic 1 2 3 4 5 6 7 8 9 10 11 12
x0 1 2 14 15 10 11 diatch
x1 3 13 10 11 dinv
x2 13 14 4 5 16 10 11 dd4and
x3 13 15 4 5 7 10 11 dd4and
x4 4 3 14 5 17 10 11 dd4and
x5 3 15 4 5 9 10 11 dd4and
x6 16 6 10 12 lvl
x7 17 8 10 12 lvl

```

```

.ends wlogic
*****
* hspice dcfl standard load subcircuit
*      input, output, power, ground
.subckt d2load 1 2 3 4
x0 1 5 3 4 dinv
x1 1 2 3 4 dinv
.ends d2load
*****
* ***** hspice version *****
* include vitesse hgaas3 models and parameters for hspice.
*****
* power supplies
vds 1 0 dc 2.0v $ element under test power supply
vss 777 0 dc -2.5v $ test load negative power supply
vload 888 0 dc 2.0v $ test load power supply

* temperature card
*.temp 85.0

* signal inputs

* next three lines used to provide test signal inputs for transient analysis
va0 100 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vmwrite 101 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vph2 102 0 pulse(0.063 0.63 4200ps 100ps 100ps 4000ps 8400ps)
vdx 103 0 pulse(0.63 0.063 8400ps 100ps 100ps 8200ps 16800ps)
vdas 104 0 0.63v

* main circuit
* dx das a0 mw ph2 expu expd oxp1 oxp2 power grnd vss
x0 103 104 100 101 102 110 111 112 113 1 0 777 wlogic
x1 110           888 0 dm10load
x2 111           121  888 0 d2load
x3 112           888 0 dm10load
x4 113           123  888 0 d2load

* measurement parameters

* next two lines are used for transient analysis
.probe dx=v(103) das=v(104) a0=v(100) mw=v(101) ph2=v(102)
+ expu=v(110) expd=v(111) oxp1=v(112) oxp2=v(113)
.probe tran p(vds) p(vss) power
.measure tran avgpwr avg p(vds)

* next 8 lines calculate vmax vmin trise tfall and tdelay :transient analysis
.meas tran vmax max v(113) from=2ns to=20ns
.meas tran vmin min v(113) from=2ns to=20ns
.meas tran vmin2 find v(113) at=10ns

```

```

.meas tran tphi trig v(102) val='(vmax-vmin)*.5' td=16ns
+ fall=1 targ v(113) val='(vmax-vmin)*.5' td=2ns fall=1
.meas tran tpls trig v(102) val='(vmax-vmin)*.5' td=12ns
+ rise=1 targ v(113) val='(vmax-vmin)*.5' td=2ns rise=1
.meas tran trise trig v(113) val='vmin+0.1*vmax' td=12ns
+ rise=1 targ v(113) val='0.9*vmax' td=12ns rise=1
.meas tran tfall trig v(113) val='0.9*vmax' td=2ns
+ fall=1 targ v(113) val='vmin2+0.1*vmax' fall=1
.meas tran tdelay trig v(102) val=.2835 td=2ns rise=1
+ targ v(112) val=-0.600 rise=1
.tran 250ps 20ns
.options scale=1e-06 brief=0 nolog measout post probe
.end
** hspice file created for circuit wlogic: transient&power @ 25.0c
***** circuit name directory
*****
circuit number to circuit name directory
number circuitname           definition multiplier
0 main circuit
 1 x0.          wlogic    1.00
 2 x1.          dm10load  1.00
 3 x2.          d2load    1.00
 4 x3.          dm10load  1.00
 5 x4.          d2load    1.00
 6 x0.x0.        dlatch    1.00
 7 x0.x1.        dinv     1.00
 8 x0.x2.        dd4and   1.00
 9 x0.x3.        dd4and   1.00
10 x0.x4.       dd4and   1.00
11 x0.x5.       dd4and   1.00
12 x0.x6.       lvl      1.00
13 x0.x7.       lvl      1.00
14 x2.x0.       dinv     1.00
15 x2.x1.       dinv     1.00
16 x4.x0.       dinv     1.00
17 x4.x1.       dinv     1.00
18 x0.x0.x0.    d2nand   1.00
19 x0.x0.x1.    dinv     1.00
20 x0.x0.x2.    d2nand   1.00
21 x0.x0.x3.    d2nand   1.00
22 x0.x0.x4.    d2nand   1.00
23 x0.x2.x0.    dinv     1.00
24 x0.x2.x1.    dinv     1.00
25 x0.x2.x2.    dinv     1.00
26 x0.x2.x3.    dinv     1.00
27 x0.x2.x4.    d4nor    1.00
28 x0.x3.x0.    dinv     1.00
29 x0.x3.x1.    dinv     1.00
30 x0.x3.x2.    dinv     1.00
31 x0.x3.x3.    dinv     1.00
32 x0.x3.x4.    d4nor    1.00

```

```

33 x0.x4.x0.      dinv   1.00
34 x0.x4.x1.      dinv   1.00
35 x0.x4.x2.      dinv   1.00
36 x0.x4.x3.      dinv   1.00
37 x0.x4.x4.      d4nor  1.00
38 x0.x5.x0.      dinv   1.00
39 x0.x5.x1.      dinv   1.00
40 x0.x5.x2.      dinv   1.00
41 x0.x5.x3.      dinv   1.00
42 x0.x5.x4.      d4nor  1.00
43 x0.x6.x0.      dinv   1.00
44 x0.x7.x0.      dinv   1.00

```

Opening plot unit= 15

file=wlogic1.pa0

```

** hspice file created for circuit wlogic: transient&power @ 25.0c
***** operating point information  tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is  0.
    node =voltage    node =voltage    node =voltage

```

```

+ 0:1   = 2.0000 0:100   = 63.0000m 0:101   = 63.0000m
+ 0:102  = 63.0000m 0:103   = 630.0000m 0:104   = 630.0000m
+ 0:110  = -1.2402 0:111   = 26.2129m 0:112   = -1.2402
+ 0:113  = 23.1689m 0:121   = 1.9920 0:123   = 1.9925
+ 0:777  = -2.5000 0:888   = 2.0000 1:13   = 636.5005m
+ 1:14   = 614.6238m 1:15   = 81.2740m 1:16   = 32.4038m
+ 1:17   = 26.2202m 3:5   = 1.9920 5:5   = 1.9925
+ 6:7   = 53.9658m 6:8   = 66.4030m 6:9   = 681.1090m
+ 8:10   = 53.0980m 8:11   = 56.9463m 8:12   = 653.4893m
+ 8:13   = 653.4893m 9:10   = 53.0980m 9:11   = 651.3630m
+ 9:12   = 651.4733m 9:13   = 651.4733m 10:10   = 651.4758m
+10:11   = 651.4758m 10:12   = 56.9463m 10:13   = 651.4758m
+11:10   = 650.4062m 11:11   = 650.2962m 11:12   = 650.4062m
+11:13   = 650.4062m 12:6   = 1.3577 12:7   = 652.4880m
+12:9   = 74.9279m 12:10   = 230.8769m 12:11   = -504.6665m
+12:12   = -1.5552 12:13   = -1.8701 12:14   = -2.1851
+12:25   = 1.9693 13:6   = 1.3583 13:7   = 652.9635m
+13:9   = 74.9209m 13:10   = 230.8713m 13:11   = -504.6721m
+13:12   = -1.5552 13:13   = -1.8701 13:14   = -2.1851
+13:25   = 1.9702 18:6   = 35.5694m 20:6   = 508.1467m
+21:6   = 34.2476m 22:6   = 51.0945m

```

Opening plot unit= 16

file=wlogic1.tr0

```

** hspice file created for circuit wlogic: transient&power @ 25.0c
***** transient analysis          tnom= 25.000 temp= 25.000

```

```

*****
avgpwr = -7.1033E-02 from= 0.0000E+00 to= 2.0000E-08
vmax = 6.3964E-01 at= 1.6750E-08
      from= 2.0000E-09 to= 2.0000E-08
vmin = -6.6850E-02 at= 1.2700E-08
      from= 2.0000E-09 to= 2.0000E-08
vmin2 = 2.6230E-02
tphl = 8.5134E-11 targ= 1.6834E-08 trig= 1.6749E-08
tplh = 2.4188E-10 targ= 1.2893E-08 trig= 1.2651E-08
trise = 4.2605E-10 targ= 1.3156E-08 trig= 1.2730E-08
tfall = 8.8808E-11 targ= 1.6880E-08 trig= 1.6791E-08
tdelay = 4.8307E-10 targ= 4.7220E-09 trig= 4.2389E-09

***** job concluded
total cpu time 46.47 seconds
job started at 9:45:34 8-feb93
job ended at 9:48:2 8-feb93

```

I am done with wlogic1.sp
Mon Feb 8 09:48:03 PST 1993

T. GaAs DRAM HSPICE Pad->Pad Simulation

The GaAs DRAM design was simulated multiple times per temperature setting using HSPICE for the transient analysis. The reason for the multiple runs arises from the use the HSPICE "option probe" which restrictes the output data file to a maximum of 32 target nodes. Additionally, the replicated GaAs DRAM data from the second and further HSPICE pad->pad simulation runs will be deleted leaving only the data unique to each.

1. Run #1 LISTING FILE

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
reading design configuration file: gdram0.cfg
setting user memory from config file to 1000000 words. (8000000 bytes)

```

***** h s p i c e 9007d 10:47:32 6-feb93 sun
** spice file created for circuit gaasdram0 1/10/93 mike morris
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
**
```

** node: 0 = gnd
** node: 1 = vdd
j0 100 101 0 0 jfet04 l=1.2 w=28.4
j1 102 103 0 0 jfet04 l=1.2 w=28.4
j2 0 101 100 0 jfet04 l=1.2 w=28.4
j3 0 101 103 0 jfet04 l=1.2 w=18.8
j4 0 103 102 0 jfet04 l=1.2 w=28.4
j5 100 100 1 0 jfet16 l=1.6 w=6.4
j6 103 103 1 0 jfet16 l=2.4 w=3.6
j7 102 102 1 0 jfet16 l=1.6 w=6.4
j8 1 102 104 0 jfet16 l=1.6 w=34.8
j9 104 100 0 0 jfet04 l=1.2 w=47.6
j10 104 100 0 0 jfet04 l=1.2 w=47.6
j11 0 100 104 0 jfet04 l=1.2 w=42.4
j12 0 100 104 0 jfet04 l=1.2 w=42.4
j13 105 1 105 248 dio16 l=2.4 w=36.4
j14 106 1 106 248 dio16 l=1.2 w=30.4
j15 105 1 105 248 dio16 l=2.4 w=52.0
j16 106 1 106 248 dio16 l=1.2 w=30.4
j17 105 1 105 248 dio16 l=2.4 w=52.0
j18 106 1 106 248 dio16 l=1.2 w=30.4
j19 106 1 106 248 dio16 l=1.2 w=30.4
j20 105 1 105 248 dio16 l=2.4 w=52.0
j21 106 1 106 248 dio16 l=1.2 w=30.4
j22 105 1 105 248 dio16 l=2.4 w=52.0
j23 106 1 106 248 dio16 l=1.2 w=30.4
j24 105 1 105 248 dio16 l=2.4 w=52.0
j25 106 1 106 248 dio16 l=1.2 w=30.4
j26 105 1 105 248 dio16 l=2.4 w=52.0
j27 106 1 106 248 dio16 l=1.2 w=30.4
j28 106 1 106 248 dio16 l=1.2 w=30.4
j29 106 1 106 248 dio16 l=1.2 w=29.2
j30 106 104 107 0 jfet04 l=1.2 w=47.6
j31 107 104 105 0 jfet04 l=1.2 w=34.8
j32 107 104 106 0 jfet04 l=1.2 w=47.6
j33 105 104 107 0 jfet04 l=1.2 w=34.8
j34 106 104 107 0 jfet04 l=1.2 w=47.6
j35 107 104 105 0 jfet04 l=1.2 w=34.8
j36 107 104 106 0 jfet04 l=1.2 w=47.6
j37 105 104 107 0 jfet04 l=1.2 w=34.8
j38 106 104 107 0 jfet04 l=1.2 w=47.6
j39 107 104 105 0 jfet04 l=1.2 w=34.8
j40 107 104 106 0 jfet04 l=1.2 w=47.6
j41 105 104 107 0 jfet04 l=1.2 w=34.8
j42 106 104 107 0 jfet04 l=1.2 w=47.6
j43 107 104 105 0 jfet04 l=1.2 w=34.8
j44 107 104 106 0 jfet04 l=1.2 w=47.6
j45 105 104 107 0 jfet04 l=1.2 w=34.8
j46 106 104 107 0 jfet04 l=1.2 w=47.6
j47 107 104 105 0 jfet04 l=1.2 w=34.8
j48 107 104 106 0 jfet04 l=1.2 w=47.6

j49 105 104 107 0 jfet04 l=1.2 w=34.8
j50 106 104 107 0 jfet04 l=1.2 w=47.6
j51 107 104 105 0 jfet04 l=1.2 w=34.8
j52 107 104 106 0 jfet04 l=1.2 w=47.6
j53 105 104 107 0 jfet04 l=1.2 w=34.8
j54 106 104 107 0 jfet04 l=1.2 w=47.6
j55 107 104 105 0 jfet04 l=1.2 w=34.8
j56 107 104 106 0 jfet04 l=1.2 w=47.6
j57 105 104 107 0 jfet04 l=1.2 w=34.8
j58 106 104 107 0 jfet04 l=1.2 w=47.6
j59 107 104 105 0 jfet04 l=1.2 w=34.8
j60 107 104 106 0 jfet04 l=1.2 w=47.6
j61 105 104 107 0 jfet04 l=1.2 w=34.8
j62 106 104 107 0 jfet04 l=1.2 w=47.6
j63 107 104 105 0 jfet04 l=1.2 w=34.8
j64 107 104 106 0 jfet04 l=1.2 w=47.6
j65 105 104 107 0 jfet04 l=1.2 w=34.8
j66 106 104 107 0 jfet04 l=1.2 w=47.6
j67 107 104 105 0 jfet04 l=1.2 w=34.8
j68 107 104 106 0 jfet04 l=1.2 w=47.6
j69 105 104 107 0 jfet04 l=1.2 w=34.8
j70 106 104 107 0 jfet04 l=1.2 w=5.2
j71 1 107 1 248 dio16 l=1.2 w=2.0
j72 107 0 107 248 dio16 l=1.2 w=48.0
j73 1 107 1 248 dio16 l=1.2 w=49.2
j74 107 0 107 248 dio16 l=1.2 w=48.0
j75 1 107 1 248 dio16 l=1.2 w=49.2
j76 107 0 107 248 dio16 l=1.2 w=48.0
j77 1 107 1 248 dio16 l=1.2 w=49.2
j78 107 0 107 248 dio16 l=1.2 w=48.0
j79 1 107 1 248 dio16 l=1.2 w=49.2
j80 107 0 107 248 dio16 l=1.2 w=48.0
j81 1 107 1 248 dio16 l=1.2 w=49.2
j82 107 0 107 248 dio16 l=1.2 w=48.0
j83 1 107 1 248 dio16 l=1.2 w=49.2
j84 108 109 0 0 jfet04 l=1.2 w=28.4
j85 110 111 0 0 jfet04 l=1.2 w=28.4
j86 0 109 108 0 jfet04 l=1.2 w=28.4
j87 0 109 111 0 jfet04 l=1.2 w=18.8
j88 0 111 110 0 jfet04 l=1.2 w=28.4
j89 108 108 1 0 jfet16 l=1.6 w=6.4
j90 111 111 1 0 jfet16 l=2.4 w=3.6
j91 110 110 1 0 jfet16 l=1.6 w=6.4
j92 1 110 112 0 jfet16 l=1.6 w=34.8
j93 112 108 0 0 jfet04 l=1.2 w=47.6
j94 112 108 0 0 jfet04 l=1.2 w=47.6
j95 0 108 112 0 jfet04 l=1.2 w=42.4
j96 0 108 112 0 jfet04 l=1.2 w=42.4
j97 113 1 113 248 dio16 l=2.4 w=36.4
j98 114 1 114 248 dio16 l=1.2 w=30.4
j99 113 1 113 248 dio16 l=2.4 w=52.0

j100 114 1 114 248 dio16 l=1.2 w=30.4
j101 113 1 113 248 dio16 l=2.4 w=52.0
j102 114 1 114 248 dio16 l=1.2 w=30.4
j103 114 1 114 248 dio16 l=1.2 w=30.4
j104 113 1 113 248 dio16 l=2.4 w=52.0
j105 114 1 114 248 dio16 l=1.2 w=30.4
j106 113 1 113 248 dio16 l=2.4 w=52.0
j107 114 1 114 248 dio16 l=1.2 w=30.4
j108 113 1 113 248 dio16 l=2.4 w=52.0
j109 114 1 114 248 dio16 l=1.2 w=30.4
j110 113 1 113 248 dio16 l=2.4 w=52.0
j111 114 1 114 248 dio16 l=1.2 w=30.4
j112 114 1 114 248 dio16 l=1.2 w=30.4
j113 114 1 114 248 dio16 l=1.2 w=29.2
j114 114 112 115 0 jfet04 l=1.2 w=47.6
j115 115 112 113 0 jfet04 l=1.2 w=34.8
j116 115 112 114 0 jfet04 l=1.2 w=47.6
j117 113 112 115 0 jfet04 l=1.2 w=34.8
j118 114 112 115 0 jfet04 l=1.2 w=47.6
j119 115 112 113 0 jfet04 l=1.2 w=34.8
j120 115 112 114 0 jfet04 l=1.2 w=47.6
j121 113 112 115 0 jfet04 l=1.2 w=34.8
j122 114 112 115 0 jfet04 l=1.2 w=47.6
j123 115 112 113 0 jfet04 l=1.2 w=34.8
j124 115 112 114 0 jfet04 l=1.2 w=47.6
j125 113 112 115 0 jfet04 l=1.2 w=34.8
j126 114 112 115 0 jfet04 l=1.2 w=47.6
j127 115 112 113 0 jfet04 l=1.2 w=34.8
j128 115 112 114 0 jfet04 l=1.2 w=47.6
j129 113 112 115 0 jfet04 l=1.2 w=34.8
j130 114 112 115 0 jfet04 l=1.2 w=47.6
j131 115 112 113 0 jfet04 l=1.2 w=34.8
j132 115 112 114 0 jfet04 l=1.2 w=47.6
j133 113 112 115 0 jfet04 l=1.2 w=34.8
j134 114 112 115 0 jfet04 l=1.2 w=47.6
j135 115 112 113 0 jfet04 l=1.2 w=34.8
j136 115 112 114 0 jfet04 l=1.2 w=47.6
j137 113 112 115 0 jfet04 l=1.2 w=34.8
j138 114 112 115 0 jfet04 l=1.2 w=47.6
j139 115 112 113 0 jfet04 l=1.2 w=34.8
j140 115 112 114 0 jfet04 l=1.2 w=47.6
j141 113 112 115 0 jfet04 l=1.2 w=34.8
j142 114 112 115 0 jfet04 l=1.2 w=47.6
j143 115 112 113 0 jfet04 l=1.2 w=34.8
j144 115 112 114 0 jfet04 l=1.2 w=47.6
j145 113 112 115 0 jfet04 l=1.2 w=34.8
j146 114 112 115 0 jfet04 l=1.2 w=47.6
j147 115 112 113 0 jfet04 l=1.2 w=34.8
j148 115 112 114 0 jfet04 l=1.2 w=47.6
j149 113 112 115 0 jfet04 l=1.2 w=34.8
j150 114 112 115 0 jfet04 l=1.2 w=47.6

j151 115 112 113 0 jfet04 l=1.2 w=34.8
j152 115 112 114 0 jfet04 l=1.2 w=47.6
j153 113 112 115 0 jfet04 l=1.2 w=34.8
j154 114 112 115 0 jfet04 l=1.2 w=5.2
j155 1 115 1 248 dio16 l=1.2 w=2.0
j156 115 0 115 248 dio16 l=1.2 w=48.0
j157 1 115 1 248 dio16 l=1.2 w=49.2
j158 115 0 115 248 dio16 l=1.2 w=48.0
j159 1 115 1 248 dio16 l=1.2 w=49.2
j160 115 0 115 248 dio16 l=1.2 w=48.0
j161 1 115 1 248 dio16 l=1.2 w=49.2
j162 115 0 115 248 dio16 l=1.2 w=48.0
j163 1 115 1 248 dio16 l=1.2 w=49.2
j164 115 0 115 248 dio16 l=1.2 w=48.0
j165 1 115 1 248 dio16 l=1.2 w=49.2
j166 115 0 115 248 dio16 l=1.2 w=48.0
j167 1 115 1 248 dio16 l=1.2 w=49.2
j168 116 117 0 0 jfet04 l=1.2 w=28.4
j169 118 119 0 0 jfet04 l=1.2 w=28.4
j170 0 117 116 0 jfet04 l=1.2 w=28.4
j171 0 117 119 0 jfet04 l=1.2 w=18.8
j172 0 119 118 0 jfet04 l=1.2 w=28.4
j173 116 116 1 0 jfet16 l=1.6 w=6.4
j174 119 119 1 0 jfet16 l=2.4 w=3.6
j175 118 118 1 0 jfet16 l=1.6 w=6.4
j176 1 118 120 0 jfet16 l=1.6 w=34.8
j177 120 116 0 0 jfet04 l=1.2 w=47.6
j178 120 116 0 0 jfet04 l=1.2 w=47.6
j179 0 116 120 0 jfet04 l=1.2 w=42.4
j180 0 116 120 0 jfet04 l=1.2 w=42.4
j181 121 1 121 248 dio16 l=2.4 w=36.4
j182 122 1 122 248 dio16 l=1.2 w=30.4
j183 121 1 121 248 dio16 l=2.4 w=52.0
j184 122 1 122 248 dio16 l=1.2 w=30.4
j185 121 1 121 248 dio16 l=2.4 w=52.0
j186 122 1 122 248 dio16 l=1.2 w=30.4
j187 122 1 122 248 dio16 l=1.2 w=30.4
j188 121 1 121 248 dio16 l=2.4 w=52.0
j189 122 1 122 248 dio16 l=1.2 w=30.4
j190 121 1 121 248 dio16 l=2.4 w=52.0
j191 122 1 122 248 dio16 l=1.2 w=30.4
j192 121 1 121 248 dio16 l=2.4 w=52.0
j193 122 1 122 248 dio16 l=1.2 w=30.4
j194 121 1 121 248 dio16 l=2.4 w=52.0
j195 122 1 122 248 dio16 l=1.2 w=30.4
j196 122 1 122 248 dio16 l=1.2 w=30.4
j197 122 1 122 248 dio16 l=1.2 w=29.2
j198 122 120 123 0 jfet04 l=1.2 w=47.6
j199 123 120 121 0 jfet04 l=1.2 w=34.8
j200 123 120 122 0 jfet04 l=1.2 w=47.6
j201 121 120 123 0 jfet04 l=1.2 w=34.8

j202 122 120 123 0 jfet04 l=1.2 w=47.6
j203 123 120 121 0 jfet04 l=1.2 w=34.8
j204 123 120 122 0 jfet04 l=1.2 w=47.6
j205 121 120 123 0 jfet04 l=1.2 w=34.8
j206 122 120 123 0 jfet04 l=1.2 w=47.6
j207 123 120 121 0 jfet04 l=1.2 w=34.8
j208 123 120 122 0 jfet04 l=1.2 w=47.6
j209 121 120 123 0 jfet04 l=1.2 w=34.8
j210 122 120 123 0 jfet04 l=1.2 w=47.6
j211 123 120 121 0 jfet04 l=1.2 w=34.8
j212 123 120 122 0 jfet04 l=1.2 w=47.6
j213 121 120 123 0 jfet04 l=1.2 w=34.8
j214 122 120 123 0 jfet04 l=1.2 w=47.6
j215 123 120 121 0 jfet04 l=1.2 w=34.8
j216 123 120 122 0 jfet04 l=1.2 w=47.6
j217 121 120 123 0 jfet04 l=1.2 w=34.8
j218 122 120 123 0 jfet04 l=1.2 w=47.6
j219 123 120 121 0 jfet04 l=1.2 w=34.8
j220 123 120 122 0 jfet04 l=1.2 w=47.6
j221 121 120 123 0 jfet04 l=1.2 w=34.8
j222 122 120 123 0 jfet04 l=1.2 w=47.6
j223 123 120 121 0 jfet04 l=1.2 w=34.8
j224 123 120 122 0 jfet04 l=1.2 w=47.6
j225 121 120 123 0 jfet04 l=1.2 w=34.8
j226 122 120 123 0 jfet04 l=1.2 w=47.6
j227 123 120 121 0 jfet04 l=1.2 w=34.8
j228 123 120 122 0 jfet04 l=1.2 w=47.6
j229 121 120 123 0 jfet04 l=1.2 w=34.8
j230 122 120 123 0 jfet04 l=1.2 w=47.6
j231 123 120 121 0 jfet04 l=1.2 w=34.8
j232 123 120 122 0 jfet04 l=1.2 w=47.6
j233 121 120 123 0 jfet04 l=1.2 w=34.8
j234 122 120 123 0 jfet04 l=1.2 w=47.6
j235 123 120 121 0 jfet04 l=1.2 w=34.8
j236 123 120 122 0 jfet04 l=1.2 w=47.6
j237 121 120 123 0 jfet04 l=1.2 w=34.8
j238 122 120 123 0 jfet04 l=1.2 w=5.2
j239 1 123 1 248 dio16 l=1.2 w=2.0
j240 123 0 123 248 dio16 l=1.2 w=48.0
j241 1 123 1 248 dio16 l=1.2 w=49.2
j242 123 0 123 248 dio16 l=1.2 w=48.0
j243 1 123 1 248 dio16 l=1.2 w=49.2
j244 123 0 123 248 dio16 l=1.2 w=48.0
j245 1 123 1 248 dio16 l=1.2 w=49.2
j246 123 0 123 248 dio16 l=1.2 w=48.0
j247 1 123 1 248 dio16 l=1.2 w=49.2
j248 123 0 123 248 dio16 l=1.2 w=48.0
j249 1 123 1 248 dio16 l=1.2 w=49.2
j250 123 0 123 248 dio16 l=1.2 w=48.0
j251 1 123 1 248 dio16 l=1.2 w=49.2
j252 124 125 0 0 jfet04 l=1.2 w=28.4

j253 126 127 0 0 jfet04 l=1.2 w=28.4
j254 0 125 124 0 jfet04 l=1.2 w=28.4
j255 0 125 127 0 jfet04 l=1.2 w=18.8
j256 0 127 126 0 jfet04 l=1.2 w=28.4
j257 124 124 1 0 jfet16 l=1.6 w=6.4
j258 127 127 1 0 jfet16 l=2.4 w=3.6
j259 126 126 1 0 jfet16 l=1.6 w=6.4
j260 1 126 128 0 jfet16 l=1.6 w=34.8
j261 128 124 0 0 jfet04 l=1.2 w=47.6
j262 128 124 0 0 jfet04 l=1.2 w=47.6
j263 0 124 128 0 jfet04 l=1.2 w=42.4
j264 0 124 128 0 jfet04 l=1.2 w=42.4
j265 129 1 129 248 dio16 l=2.4 w=36.4
j266 130 1 130 248 dio16 l=1.2 w=30.4
j267 129 1 129 248 dio16 l=2.4 w=52.0
j268 130 1 130 248 dio16 l=1.2 w=30.4
j269 129 1 129 248 dio16 l=2.4 w=52.0
j270 130 1 130 248 dio16 l=1.2 w=30.4
j271 130 1 130 248 dio16 l=1.2 w=30.4
j272 129 1 129 248 dio16 l=2.4 w=52.0
j273 130 1 130 248 dio16 l=1.2 w=30.4
j274 129 1 129 248 dio16 l=2.4 w=52.0
j275 130 1 130 248 dio16 l=1.2 w=30.4
j276 129 1 129 248 dio16 l=2.4 w=52.0
j277 130 1 130 248 dio16 l=1.2 w=30.4
j278 129 1 129 248 dio16 l=2.4 w=52.0
j279 130 1 130 248 dio16 l=1.2 w=30.4
j280 130 1 130 248 dio16 l=1.2 w=30.4
j281 130 1 130 248 dio16 l=1.2 w=29.2
j282 130 128 131 0 jfet04 l=1.2 w=47.6
j283 131 128 129 0 jfet04 l=1.2 w=34.8
j284 131 128 130 0 jfet04 l=1.2 w=47.6
j285 129 128 131 0 jfet04 l=1.2 w=34.8
j286 130 128 131 0 jfet04 l=1.2 w=47.6
j287 131 128 129 0 jfet04 l=1.2 w=34.8
j288 131 128 130 0 jfet04 l=1.2 w=47.6
j289 129 128 131 0 jfet04 l=1.2 w=34.8
j290 130 128 131 0 jfet04 l=1.2 w=47.6
j291 131 128 129 0 jfet04 l=1.2 w=34.8
j292 131 128 130 0 jfet04 l=1.2 w=47.6
j293 129 128 131 0 jfet04 l=1.2 w=34.8
j294 130 128 131 0 jfet04 l=1.2 w=47.6
j295 131 128 129 0 jfet04 l=1.2 w=34.8
j296 131 128 130 0 jfet04 l=1.2 w=47.6
j297 129 128 131 0 jfet04 l=1.2 w=34.8
j298 130 128 131 0 jfet04 l=1.2 w=47.6
j299 131 128 129 0 jfet04 l=1.2 w=34.8
j300 131 128 130 0 jfet04 l=1.2 w=47.6
j301 129 128 131 0 jfet04 l=1.2 w=34.8
j302 130 128 131 0 jfet04 l=1.2 w=47.6
j303 131 128 129 0 jfet04 l=1.2 w=34.8

j304 131 128 130 0 jfet04 l=1.2 w=47.6
j305 129 128 131 0 jfet04 l=1.2 w=34.8
j306 130 128 131 0 jfet04 l=1.2 w=47.6
j307 131 128 129 0 jfet04 l=1.2 w=34.8
j308 131 128 130 0 jfet04 l=1.2 w=47.6
j309 129 128 131 0 jfet04 l=1.2 w=34.8
j310 130 128 131 0 jfet04 l=1.2 w=47.6
j311 131 128 129 0 jfet04 l=1.2 w=34.8
j312 131 128 130 0 jfet04 l=1.2 w=47.6
j313 129 128 131 0 jfet04 l=1.2 w=34.8
j314 130 128 131 0 jfet04 l=1.2 w=47.6
j315 131 128 129 0 jfet04 l=1.2 w=34.8
j316 131 128 130 0 jfet04 l=1.2 w=47.6
j317 129 128 131 0 jfet04 l=1.2 w=34.8
j318 130 128 131 0 jfet04 l=1.2 w=47.6
j319 131 128 129 0 jfet04 l=1.2 w=34.8
j320 131 128 130 0 jfet04 l=1.2 w=47.6
j321 129 128 131 0 jfet04 l=1.2 w=34.8
j322 130 128 131 0 jfet04 l=1.2 w=5.2
j323 1 131 1 248 dio16 l=1.2 w=2.0
j324 131 0 131 248 dio16 l=1.2 w=48.0
j325 1 131 1 248 dio16 l=1.2 w=49.2
j326 131 0 131 248 dio16 l=1.2 w=48.0
j327 1 131 1 248 dio16 l=1.2 w=49.2
j328 131 0 131 248 dio16 l=1.2 w=48.0
j329 1 131 1 248 dio16 l=1.2 w=49.2
j330 131 0 131 248 dio16 l=1.2 w=48.0
j331 1 131 1 248 dio16 l=1.2 w=49.2
j332 131 0 131 248 dio16 l=1.2 w=48.0
j333 1 131 1 248 dio16 l=1.2 w=49.2
j334 131 0 131 248 dio16 l=1.2 w=48.0
j335 1 131 1 248 dio16 l=1.2 w=49.2
j336 132 133 0 0 jfet04 l=1.2 w=28.4
j337 134 135 0 0 jfet04 l=1.2 w=28.4
j338 0 133 132 0 jfet04 l=1.2 w=28.4
j339 0 133 135 0 jfet04 l=1.2 w=18.8
j340 0 135 134 0 jfet04 l=1.2 w=28.4
j341 132 132 1 0 jfet16 l=1.6 w=6.4
j342 135 135 1 0 jfet16 l=2.4 w=3.6
j343 134 134 1 0 jfet16 l=1.6 w=6.4
j344 1 134 136 0 jfet16 l=1.6 w=34.8
j345 136 132 0 0 jfet04 l=1.2 w=47.6
j346 136 132 0 0 jfet04 l=1.2 w=47.6
j347 0 132 136 0 jfet04 l=1.2 w=42.4
j348 0 132 136 0 jfet04 l=1.2 w=42.4
j349 137 1 137 248 dio16 l=2.4 w=36.4
j350 138 1 138 248 dio16 l=1.2 w=30.4
j351 137 1 137 248 dio16 l=2.4 w=52.0
j352 138 1 138 248 dio16 l=1.2 w=30.4
j353 137 1 137 248 dio16 l=2.4 w=52.0
j354 138 1 138 248 dio16 l=1.2 w=30.4

j355 138 1 138 248 dio16 l=1.2 w=30.4
j356 137 1 137 248 dio16 l=2.4 w=52.0
j357 138 1 138 248 dio16 l=1.2 w=30.4
j358 137 1 137 248 dio16 l=2.4 w=52.0
j359 138 1 138 248 dio16 l=1.2 w=30.4
j360 137 1 137 248 dio16 l=2.4 w=52.0
j361 138 1 138 248 dio16 l=1.2 w=30.4
j362 137 1 137 248 dio16 l=2.4 w=52.0
j363 138 1 138 248 dio16 l=1.2 w=30.4
j364 138 1 138 248 dio16 l=1.2 w=30.4
j365 138 1 138 248 dio16 l=1.2 w=29.2
j366 138 136 139 0 jfet04 l=1.2 w=47.6
j367 139 136 137 0 jfet04 l=1.2 w=34.8
j368 139 136 138 0 jfet04 l=1.2 w=47.6
j369 137 136 139 0 jfet04 l=1.2 w=34.8
j370 138 136 139 0 jfet04 l=1.2 w=47.6
j371 139 136 137 0 jfet04 l=1.2 w=34.8
j372 139 136 138 0 jfet04 l=1.2 w=47.6
j373 137 136 139 0 jfet04 l=1.2 w=34.8
j374 138 136 139 0 jfet04 l=1.2 w=47.6
j375 139 136 137 0 jfet04 l=1.2 w=34.8
j376 139 136 138 0 jfet04 l=1.2 w=47.6
j377 137 136 139 0 jfet04 l=1.2 w=34.8
j378 138 136 139 0 jfet04 l=1.2 w=47.6
j379 139 136 137 0 jfet04 l=1.2 w=34.8
j380 139 136 138 0 jfet04 l=1.2 w=47.6
j381 137 136 139 0 jfet04 l=1.2 w=34.8
j382 138 136 139 0 jfet04 l=1.2 w=47.6
j383 139 136 137 0 jfet04 l=1.2 w=34.8
j384 139 136 138 0 jfet04 l=1.2 w=47.6
j385 137 136 139 0 jfet04 l=1.2 w=34.8
j386 138 136 139 0 jfet04 l=1.2 w=47.6
j387 139 136 137 0 jfet04 l=1.2 w=34.8
j388 139 136 138 0 jfet04 l=1.2 w=47.6
j389 137 136 139 0 jfet04 l=1.2 w=34.8
j390 138 136 139 0 jfet04 l=1.2 w=47.6
j391 139 136 137 0 jfet04 l=1.2 w=34.8
j392 139 136 138 0 jfet04 l=1.2 w=47.6
j393 137 136 139 0 jfet04 l=1.2 w=34.8
j394 138 136 139 0 jfet04 l=1.2 w=47.6
j395 139 136 137 0 jfet04 l=1.2 w=34.8
j396 139 136 138 0 jfet04 l=1.2 w=47.6
j397 137 136 139 0 jfet04 l=1.2 w=34.8
j398 138 136 139 0 jfet04 l=1.2 w=47.6
j399 139 136 137 0 jfet04 l=1.2 w=34.8
j400 139 136 138 0 jfet04 l=1.2 w=47.6
j401 137 136 139 0 jfet04 l=1.2 w=34.8
j402 138 136 139 0 jfet04 l=1.2 w=47.6
j403 139 136 137 0 jfet04 l=1.2 w=34.8
j404 139 136 138 0 jfet04 l=1.2 w=47.6
j405 137 136 139 0 jfet04 l=1.2 w=34.8

j406 138 136 139 0 jfet04 l=1.2 w=5.2
j407 1 139 1 248 dio16 l=1.2 w=2.0
j408 139 0 139 248 dio16 l=1.2 w=48.0
j409 1 139 1 248 dio16 l=1.2 w=49.2
j410 139 0 139 248 dio16 l=1.2 w=48.0
j411 1 139 1 248 dio16 l=1.2 w=49.2
j412 139 0 139 248 dio16 l=1.2 w=48.0
j413 1 139 1 248 dio16 l=1.2 w=49.2
j414 139 0 139 248 dio16 l=1.2 w=48.0
j415 1 139 1 248 dio16 l=1.2 w=49.2
j416 139 0 139 248 dio16 l=1.2 w=48.0
j417 1 139 1 248 dio16 l=1.2 w=49.2
j418 139 0 139 248 dio16 l=1.2 w=48.0
j419 1 139 1 248 dio16 l=1.2 w=49.2
j420 140 141 0 0 jfet04 l=1.2 w=28.4
j421 142 143 0 0 jfet04 l=1.2 w=28.4
j422 0 141 140 0 jfet04 l=1.2 w=28.4
j423 0 141 143 0 jfet04 l=1.2 w=18.8
j424 0 143 142 0 jfet04 l=1.2 w=28.4
j425 140 140 1 0 jfet16 l=1.6 w=6.4
j426 143 143 1 0 jfet16 l=2.4 w=3.6
j427 142 142 1 0 jfet16 l=1.6 w=6.4
j428 1 142 144 0 jfet16 l=1.6 w=34.8
j429 144 140 0 0 jfet04 l=1.2 w=47.6
j430 144 140 0 0 jfet04 l=1.2 w=47.6
j431 0 140 144 0 jfet04 l=1.2 w=42.4
j432 0 140 144 0 jfet04 l=1.2 w=42.4
j433 145 1 145 248 dio16 l=2.4 w=36.4
j434 146 1 146 248 dio16 l=1.2 w=30.4
j435 145 1 145 248 dio16 l=2.4 w=52.0
j436 146 1 146 248 dio16 l=1.2 w=30.4
j437 145 1 145 248 dio16 l=2.4 w=52.0
j438 146 1 146 248 dio16 l=1.2 w=30.4
j439 146 1 146 248 dio16 l=1.2 w=30.4
j440 145 1 145 248 dio16 l=2.4 w=52.0
j441 146 1 146 248 dio16 l=1.2 w=30.4
j442 145 1 145 248 dio16 l=2.4 w=52.0
j443 146 1 146 248 dio16 l=1.2 w=30.4
j444 145 1 145 248 dio16 l=2.4 w=52.0
j445 146 1 146 248 dio16 l=1.2 w=30.4
j446 145 1 145 248 dio16 l=2.4 w=52.0
j447 146 1 146 248 dio16 l=1.2 w=30.4
j448 146 1 146 248 dio16 l=1.2 w=30.4
j449 146 1 146 248 dio16 l=1.2 w=29.2
j450 146 144 147 0 jfet04 l=1.2 w=47.6
j451 147 144 145 0 jfet04 l=1.2 w=34.8
j452 147 144 146 0 jfet04 l=1.2 w=47.6
j453 145 144 147 0 jfet04 l=1.2 w=34.8
j454 146 144 147 0 jfet04 l=1.2 w=47.6
j455 147 144 145 0 jfet04 l=1.2 w=34.8
j456 147 144 146 0 jfet04 l=1.2 w=47.6

j457 145 144 147 0 jfet04 l=1.2 w=34.8
j458 146 144 147 0 jfet04 l=1.2 w=47.6
j459 147 144 145 0 jfet04 l=1.2 w=34.8
j460 147 144 146 0 jfet04 l=1.2 w=47.6
j461 145 144 147 0 jfet04 l=1.2 w=34.8
j462 146 144 147 0 jfet04 l=1.2 w=47.6
j463 147 144 145 0 jfet04 l=1.2 w=34.8
j464 147 144 146 0 jfet04 l=1.2 w=47.6
j465 145 144 147 0 jfet04 l=1.2 w=34.8
j466 146 144 147 0 jfet04 l=1.2 w=47.6
j467 147 144 145 0 jfet04 l=1.2 w=34.8
j468 147 144 146 0 jfet04 l=1.2 w=47.6
j469 145 144 147 0 jfet04 l=1.2 w=34.8
j470 146 144 147 0 jfet04 l=1.2 w=47.6
j471 147 144 145 0 jfet04 l=1.2 w=34.8
j472 147 144 146 0 jfet04 l=1.2 w=47.6
j473 145 144 147 0 jfet04 l=1.2 w=34.8
j474 146 144 147 0 jfet04 l=1.2 w=47.6
j475 147 144 145 0 jfet04 l=1.2 w=34.8
j476 147 144 146 0 jfet04 l=1.2 w=47.6
j477 145 144 147 0 jfet04 l=1.2 w=34.8
j478 146 144 147 0 jfet04 l=1.2 w=47.6
j479 147 144 145 0 jfet04 l=1.2 w=34.8
j480 147 144 146 0 jfet04 l=1.2 w=47.6
j481 145 144 147 0 jfet04 l=1.2 w=34.8
j482 146 144 147 0 jfet04 l=1.2 w=47.6
j483 147 144 145 0 jfet04 l=1.2 w=34.8
j484 147 144 146 0 jfet04 l=1.2 w=47.6
j485 145 144 147 0 jfet04 l=1.2 w=34.8
j486 146 144 147 0 jfet04 l=1.2 w=47.6
j487 147 144 145 0 jfet04 l=1.2 w=34.8
j488 147 144 146 0 jfet04 l=1.2 w=47.6
j489 145 144 147 0 jfet04 l=1.2 w=34.8
j490 146 144 147 0 jfet04 l=1.2 w=5.2
j491 1 147 1 248 dio16 l=1.2 w=2.0
j492 147 0 147 248 dio16 l=1.2 w=48.0
j493 1 147 1 248 dio16 l=1.2 w=49.2
j494 147 0 147 248 dio16 l=1.2 w=48.0
j495 1 147 1 248 dio16 l=1.2 w=49.2
j496 147 0 147 248 dio16 l=1.2 w=48.0
j497 1 147 1 248 dio16 l=1.2 w=49.2
j498 147 0 147 248 dio16 l=1.2 w=48.0
j499 1 147 1 248 dio16 l=1.2 w=49.2
j500 147 0 147 248 dio16 l=1.2 w=48.0
j501 1 147 1 248 dio16 l=1.2 w=49.2
j502 147 0 147 248 dio16 l=1.2 w=48.0
j503 1 147 1 248 dio16 l=1.2 w=49.2
j504 1 148 148 0 jfet16 l=1.2 w=6.0
j505 149 149 1 0 jfet16 l=1.2 w=6.0
j506 1 150 150 0 jfet16 l=1.2 w=6.0
j507 151 151 1 0 jfet16 l=1.2 w=6.0

j508 1 152 152 0 jfet16 l=1.2 w=6.0
j509 1 153 153 0 jfet16 l=1.2 w=6.0
j510 154 154 1 0 jfet16 l=1.2 w=6.0
j511 1 155 155 0 jfet16 l=1.2 w=6.0
j512 156 156 1 0 jfet16 l=1.2 w=6.0
j513 1 157 157 0 jfet16 l=1.2 w=6.0
j514 1 158 158 0 jfet16 l=1.2 w=6.0
j515 159 159 1 0 jfet16 l=1.2 w=6.0
j516 1 160 160 0 jfet16 l=1.2 w=6.0
j517 161 161 1 0 jfet16 l=1.2 w=6.0
j518 1 162 162 0 jfet16 l=1.2 w=6.0
j519 1 163 163 0 jfet16 l=1.2 w=6.0
j520 164 164 1 0 jfet16 l=1.2 w=6.0
j521 1 165 165 0 jfet16 l=1.2 w=6.0
j522 166 166 1 0 jfet16 l=1.2 w=6.0
j523 1 167 167 0 jfet16 l=1.2 w=6.0
j524 148 168 0 0 jfet04 l=1.2 w=48.0
j525 0 168 148 0 jfet04 l=1.2 w=48.0
j526 149 169 0 0 jfet04 l=1.2 w=48.0
j527 0 169 149 0 jfet04 l=1.2 w=48.0
j528 150 170 0 0 jfet04 l=1.2 w=48.0
j529 0 170 150 0 jfet04 l=1.2 w=48.0
j530 151 171 0 0 jfet04 l=1.2 w=48.0
j531 0 171 151 0 jfet04 l=1.2 w=48.0
j532 152 151 0 0 jfet04 l=1.2 w=48.0
j533 0 151 152 0 jfet04 l=1.2 w=48.0
j534 152 150 0 0 jfet04 l=1.2 w=48.0
j535 0 150 152 0 jfet04 l=1.2 w=48.0
j536 152 149 0 0 jfet04 l=1.2 w=48.0
j537 0 149 152 0 jfet04 l=1.2 w=48.0
j538 152 148 0 0 jfet04 l=1.2 w=48.0
j539 0 148 152 0 jfet04 l=1.2 w=48.0
j540 153 172 0 0 jfet04 l=1.2 w=48.0
j541 0 172 153 0 jfet04 l=1.2 w=48.0
j542 154 173 0 0 jfet04 l=1.2 w=48.0
j543 0 173 154 0 jfet04 l=1.2 w=48.0
j544 155 174 0 0 jfet04 l=1.2 w=48.0
j545 0 174 155 0 jfet04 l=1.2 w=48.0
j546 156 175 0 0 jfet04 l=1.2 w=48.0
j547 0 175 156 0 jfet04 l=1.2 w=48.0
j548 157 156 0 0 jfet04 l=1.2 w=48.0
j549 0 156 157 0 jfet04 l=1.2 w=48.0
j550 157 155 0 0 jfet04 l=1.2 w=48.0
j551 0 155 157 0 jfet04 l=1.2 w=48.0
j552 157 154 0 0 jfet04 l=1.2 w=48.0
j553 0 154 157 0 jfet04 l=1.2 w=48.0
j554 157 153 0 0 jfet04 l=1.2 w=48.0
j555 0 153 157 0 jfet04 l=1.2 w=48.0
j556 158 168 0 0 jfet04 l=1.2 w=48.0
j557 0 168 158 0 jfet04 l=1.2 w=48.0
j558 159 174 0 0 jfet04 l=1.2 w=48.0

j559 0 174 159 0 jfet04 l=1.2 w=48.0
j560 160 175 0 0 jfet04 l=1.2 w=48.0
j561 0 175 160 0 jfet04 l=1.2 w=48.0
j562 161 172 0 0 jfet04 l=1.2 w=48.0
j563 0 172 161 0 jfet04 l=1.2 w=48.0
j564 162 161 0 0 jfet04 l=1.2 w=48.0
j565 0 161 162 0 jfet04 l=1.2 w=48.0
j566 162 160 0 0 jfet04 l=1.2 w=48.0
j567 0 160 162 0 jfet04 l=1.2 w=48.0
j568 162 159 0 0 jfet04 l=1.2 w=48.0
j569 0 159 162 0 jfet04 l=1.2 w=48.0
j570 162 158 0 0 jfet04 l=1.2 w=48.0
j571 0 158 162 0 jfet04 l=1.2 w=48.0
j572 163 168 0 0 jfet04 l=1.2 w=48.0
j573 0 168 163 0 jfet04 l=1.2 w=48.0
j574 164 174 0 0 jfet04 l=1.2 w=48.0
j575 0 174 164 0 jfet04 l=1.2 w=48.0
j576 165 169 0 0 jfet04 l=1.2 w=48.0
j577 0 169 165 0 jfet04 l=1.2 w=48.0
j578 166 171 0 0 jfet04 l=1.2 w=48.0
j579 0 171 166 0 jfet04 l=1.2 w=48.0
j580 167 166 0 0 jfet04 l=1.2 w=48.0
j581 0 166 167 0 jfet04 l=1.2 w=48.0
j582 167 165 0 0 jfet04 l=1.2 w=48.0
j583 0 165 167 0 jfet04 l=1.2 w=48.0
j584 167 164 0 0 jfet04 l=1.2 w=48.0
j585 0 164 167 0 jfet04 l=1.2 w=48.0
j586 167 163 0 0 jfet04 l=1.2 w=48.0
j587 0 163 167 0 jfet04 l=1.2 w=48.0
j588 176 177 178 0 jfet16 l=1.2 w=3.2
j589 168 179 180 0 jfet16 l=1.2 w=8.0
j590 181 182 168 0 jfet16 l=1.2 w=8.0
j591 178 183 168 0 jfet16 l=1.2 w=8.0
j592 1 184 168 0 jfet16 l=1.2 w=62.0
j593 185 177 168 0 jfet16 l=1.2 w=6.0
j594 186 187 168 0 jfet16 l=1.2 w=8.0
j595 168 184 1 0 jfet16 l=1.2 w=62.0
j596 168 188 189 0 jfet16 l=1.2 w=8.0
j597 1 184 168 0 jfet16 l=1.2 w=62.0
j598 168 190 0 0 jfet04 l=1.2 w=6.0
j599 168 174 0 0 jfet04 l=1.2 w=70.0
j600 0 174 168 0 jfet04 l=1.2 w=70.0
j601 1 191 168 0 jfet16 l=1.2 w=9.2
j602 168 174 0 0 jfet04 l=1.2 w=70.0
j603 168 177 174 0 jfet16 l=1.2 w=17.2
j604 0 168 174 0 jfet04 l=1.2 w=70.0
j605 174 168 0 0 jfet04 l=1.2 w=70.0
j606 1 191 174 0 jfet16 l=1.2 w=9.2
j607 0 192 174 0 jfet04 l=1.2 w=6.0
j608 0 168 174 0 jfet04 l=1.2 w=70.0
j609 193 194 174 0 jfet16 l=1.2 w=8.0

j610 174 195 1 0 jfet16 l=1.2 w=62.0
j611 196 152 0 0 jfet04 l=1.2 w=48.0
j612 0 152 196 0 jfet04 l=1.2 w=48.0
j613 196 157 0 0 jfet04 l=1.2 w=48.0
j614 0 157 1 0 jfet04 l=1.2 w=48.0
j615 196 162 0 0 jfet04 l=1.2 w=48.0
j616 0 162 196 0 jfet04 l=1.2 w=48.0
j617 196 167 0 0 jfet04 l=1.2 w=48.0
j618 0 167 196 0 jfet04 l=1.2 w=48.0
j619 197 196 0 0 jfet04 l=1.2 w=48.0
j620 0 196 197 0 jfet04 l=1.2 w=48.0
j621 173 168 0 0 jfet04 l=1.2 w=48.0
j622 0 168 173 0 jfet04 l=1.2 w=48.0
j623 170 174 0 0 jfet04 l=1.2 w=48.0
j624 0 174 170 0 jfet04 l=1.2 w=48.0
j625 171 175 0 0 jfet04 l=1.2 w=48.0
j626 0 175 171 0 jfet04 l=1.2 w=48.0
j627 172 169 0 0 jfet04 l=1.2 w=48.0
j628 0 169 172 0 jfet04 l=1.2 w=48.0
j629 198 169 0 0 jfet04 l=1.2 w=48.0
j630 0 169 198 0 jfet04 l=1.2 w=48.0
j631 198 175 0 0 jfet04 l=1.2 w=48.0
j632 0 175 198 0 jfet04 l=1.2 w=48.0
j633 199 198 0 0 jfet04 l=1.2 w=48.0
j634 0 198 199 0 jfet04 l=1.2 w=48.0
j635 200 199 0 0 jfet04 l=1.2 w=48.0
j636 0 199 200 0 jfet04 l=1.2 w=48.0
j637 201 202 0 0 jfet04 l=1.2 w=48.0
j638 0 202 201 0 jfet04 l=1.2 w=48.0
j639 203 200 0 0 jfet04 l=1.2 w=48.0
j640 0 200 203 0 jfet04 l=1.2 w=48.0
j641 203 201 0 0 jfet04 l=1.2 w=48.0
j642 0 201 203 0 jfet04 l=1.2 w=48.0
j643 204 197 0 0 jfet04 l=1.2 w=48.0
j644 0 197 204 0 jfet04 l=1.2 w=48.0
j645 174 205 206 0 jfet16 l=1.2 w=8.0
j646 1 195 174 0 jfet16 l=1.2 w=62.0
j647 185 177 174 0 jfet16 l=1.2 w=6.0
j648 1 196 196 0 jfet16 l=1.2 w=6.0
j649 197 197 1 0 jfet16 l=1.2 w=6.0
j650 1 173 173 0 jfet16 l=1.2 w=6.0
j651 170 170 1 0 jfet16 l=1.2 w=6.0
j652 1 171 171 0 jfet16 l=1.2 w=6.0
j653 172 172 1 0 jfet16 l=1.2 w=6.0
j654 1 198 198 0 jfet16 l=1.2 w=6.0
j655 199 199 1 0 jfet16 l=1.2 w=6.0
j656 1 200 200 0 jfet16 l=1.2 w=6.0
j657 201 201 1 0 jfet16 l=1.2 w=6.0
j658 1 203 203 0 jfet16 l=1.2 w=6.0
j659 204 204 1 0 jfet16 l=1.2 w=6.0
j660 207 197 0 0 jfet04 l=1.2 w=64.0

j661 0 197 207 0 jfet04 l=1.2 w=64.0
j662 207 197 0 0 jfet04 l=1.2 w=64.0
j663 208 203 207 0 jfet04 l=1.2 w=64.0
j664 207 203 208 0 jfet04 l=1.2 w=64.0
j665 208 203 207 0 jfet04 l=1.2 w=64.0
j666 209 208 141 0 jfet04 l=1.2 w=64.0
j667 141 208 209 0 jfet04 l=1.2 w=64.0
j668 209 208 141 0 jfet04 l=1.2 w=64.0
j669 0 210 209 0 jfet04 l=1.2 w=64.0
j670 209 210 0 0 jfet04 l=1.2 w=64.0
j671 0 210 209 0 jfet04 l=1.2 w=64.0
j672 211 203 0 0 jfet04 l=1.2 w=64.0
j673 0 203 211 0 jfet04 l=1.2 w=64.0
j674 211 203 0 0 jfet04 l=1.2 w=64.0
j675 212 204 211 0 jfet04 l=1.2 w=64.0
j676 211 204 212 0 jfet04 l=1.2 w=64.0
j677 212 204 211 0 jfet04 l=1.2 w=64.0
j678 213 212 210 0 jfet04 l=1.2 w=64.0
j679 210 212 213 0 jfet04 l=1.2 w=64.0
j680 213 212 210 0 jfet04 l=1.2 w=64.0
j681 0 141 213 0 jfet04 l=1.2 w=64.0
j682 213 141 0 0 jfet04 l=1.2 w=64.0
j683 0 141 213 0 jfet04 l=1.2 w=64.0
j684 174 195 1 0 jfet16 l=1.2 w=62.0
j685 174 214 215 0 jfet16 l=1.2 w=8.0
j686 216 217 174 0 jfet16 l=1.2 w=8.0
j687 218 219 174 0 jfet16 l=1.2 w=8.0
j688 1 220 220 0 jfet16 l=1.2 w=6.0
j689 1 221 221 0 jfet16 l=1.2 w=6.0
j690 1 222 222 0 jfet16 l=1.2 w=6.0
j691 1 223 223 0 jfet16 l=1.2 w=6.0
j692 208 208 1 0 jfet16 l=1.2 w=6.0
j693 141 141 1 0 jfet16 l=1.2 w=6.0
j694 212 212 1 0 jfet16 l=1.2 w=6.0
j695 210 210 1 0 jfet16 l=1.2 w=6.0
j696 176 177 218 0 jfet16 l=1.2 w=3.2
j697 224 224 1 0 jfet16 l=1.2 w=6.0
j698 224 225 0 0 jfet04 l=1.2 w=48.0
j699 0 225 224 0 jfet04 l=1.2 w=48.0
j700 226 225 0 0 jfet04 l=1.2 w=64.0
j701 0 225 226 0 jfet04 l=1.2 w=64.0
j702 226 225 0 0 jfet04 l=1.2 w=64.0
j703 220 227 226 0 jfet04 l=1.2 w=64.0
j704 226 227 220 0 jfet04 l=1.2 w=64.0
j705 220 227 226 0 jfet04 l=1.2 w=64.0
j706 228 220 221 0 jfet04 l=1.2 w=64.0
j707 221 220 228 0 jfet04 l=1.2 w=64.0
j708 228 220 221 0 jfet04 l=1.2 w=64.0
j709 0 223 228 0 jfet04 l=1.2 w=64.0
j710 228 223 0 0 jfet04 l=1.2 w=64.0
j711 0 223 228 0 jfet04 l=1.2 w=64.0

j712 229 227 0 0 jfet04 l=1.2 w=64.0
j713 0 227 229 0 jfet04 l=1.2 w=64.0
j714 229 227 0 0 jfet04 l=1.2 w=64.0
j715 222 224 229 0 jfet04 l=1.2 w=64.0
j716 229 224 222 0 jfet04 l=1.2 w=64.0
j717 222 224 229 0 jfet04 l=1.2 w=64.0
j718 230 222 223 0 jfet04 l=1.2 w=64.0
j719 223 222 230 0 jfet04 l=1.2 w=64.0
j720 230 222 273 0 jfet04 l=1.2 w=64.0
j721 0 221 230 0 jfet04 l=1.2 w=64.0
j722 230 221 0 0 jfet04 l=1.2 w=64.0
j723 0 221 230 0 jfet04 l=1.2 w=64.0
j724 1 231 231 0 jfet16 l=1.2 w=6.0
j725 232 232 1 0 jfet16 l=1.2 w=6.0
j726 1 233 233 0 jfet16 l=1.2 w=6.0
j727 234 234 1 0 jfet16 l=1.2 w=6.0
j728 1 192 192 0 jfet16 l=1.2 w=6.0
j729 1 235 235 0 jfet16 l=1.2 w=6.0
j730 236 236 1 0 jfet16 l=1.2 w=6.0
j731 1 237 237 0 jfet16 l=1.2 w=6.0
j732 238 238 1 0 jfet16 l=1.2 w=6.0
j733 1 239 239 0 jfet16 l=1.2 w=6.0
j734 240 240 1 0 jfet16 l=1.2 w=6.0
j735 241 241 1 0 jfet16 l=1.2 w=3.2
j736 231 242 0 0 jfet04 l=1.2 w=48.0
j737 0 242 231 0 jfet04 l=1.2 w=48.0
j738 232 223 0 0 jfet04 l=1.2 w=48.0
j739 0 223 232 0 jfet04 l=1.2 w=48.0
j740 233 243 0 0 jfet04 l=1.2 w=48.0
j741 0 243 233 0 jfet04 l=1.2 w=48.0
j742 234 244 0 0 jfet04 l=1.2 w=48.0
j743 0 244 234 0 jfet04 l=1.2 w=48.0
j744 192 234 0 0 jfet04 l=1.2 w=48.0
j745 0 234 192 0 jfet04 l=1.2 w=48.0
j746 192 233 0 0 jfet04 l=1.2 w=48.0
j747 0 233 192 0 jfet04 l=1.2 w=48.0
j748 192 232 0 0 jfet04 l=1.2 w=48.0
j749 0 232 192 0 jfet04 l=1.2 w=48.0
j750 192 231 0 0 jfet04 l=1.2 w=48.0
j751 0 231 192 0 jfet04 l=1.2 w=48.0
j752 235 242 0 0 jfet04 l=1.2 w=48.0
j753 0 242 235 0 jfet04 l=1.2 w=48.0
j754 236 221 0 0 jfet04 l=1.2 w=48.0
j755 0 221 236 0 jfet04 l=1.2 w=48.0
j756 237 244 0 0 jfet04 l=1.2 w=48.0
j757 0 244 237 0 jfet04 l=1.2 w=48.0
j758 238 243 0 0 jfet04 l=1.2 w=48.0
j759 0 243 238 0 jfet04 l=1.2 w=48.0
j760 239 238 0 0 jfet04 l=1.2 w=48.0
j761 0 238 239 0 jfet04 l=1.2 w=48.0
j762 239 237 0 0 jfet04 l=1.2 w=48.0

j763 0 237 239 0 jfet04 l=1.2 w=48.0
j764 239 236 0 0 jfet04 l=1.2 w=48.0
j765 0 236 239 0 jfet04 l=1.2 w=48.0
j766 239 235 0 0 jfet04 l=1.2 w=48.0
j767 0 235 239 0 jfet04 l=1.2 w=48.0
j768 240 239 0 0 jfet04 l=1.2 w=48.0
j769 0 239 240 0 jfet04 l=1.2 w=48.0
j770 245 240 1 0 jfet04 l=1.2 w=20.0
j771 0 246 241 0 jfet16 l=1.2 w=10.0
j772 247 241 1 0 jfet16 l=1.2 w=20.0
j773 248 249 248 248 dio16 l=1.2 w=10.0
j774 246 245 246 248 dio16 l=1.2 w=4.0
j775 246 248 248 0 jfet20 l=3.2 w=3.2
j776 250 247 250 248 dio16 l=1.2 w=20.0
j777 249 251 249 248 dio16 l=1.2 w=10.0
j778 248 248 195 0 jfet16 l=1.2 w=12.0
j779 251 252 251 248 dio16 l=1.2 w=10.0
j780 252 195 252 248 dio16 l=1.2 w=10.0
j781 195 250 195 248 dio16 l=1.2 w=20.0
j782 242 253 0 0 jfet04 l=1.2 w=48.0
j783 0 253 242 0 jfet04 l=1.2 w=48.0
j784 254 253 0 0 jfet04 l=1.2 w=48.0
j785 0 253 254 0 jfet04 l=1.2 w=48.0
j786 255 223 0 0 jfet04 l=1.2 w=48.0
j787 0 223 255 0 jfet04 l=1.2 w=48.0
j788 256 243 0 0 jfet04 l=1.2 w=48.0
j789 0 243 256 0 jfet04 l=1.2 w=48.0
j790 257 244 0 0 jfet04 l=1.2 w=48.0
j791 0 244 257 0 jfet04 l=1.2 w=48.0
j792 190 257 0 0 jfet04 l=1.2 w=48.0
j793 0 257 190 0 jfet04 l=1.2 w=48.0
j794 190 256 0 0 jfet04 l=1.2 w=48.0
j795 0 256 190 0 jfet04 l=1.2 w=48.0
j796 190 255 0 0 jfet04 l=1.2 w=48.0
j797 0 255 190 0 jfet04 l=1.2 w=48.0
j798 190 254 0 0 jfet04 l=1.2 w=48.0
j799 0 254 190 0 jfet04 l=1.2 w=48.0
j800 258 253 0 0 jfet04 l=1.2 w=48.0
j801 0 253 258 0 jfet04 l=1.2 w=48.0
j802 259 221 0 0 jfet04 l=1.2 w=48.0
j803 0 221 259 0 jfet04 l=1.2 w=48.0
j804 260 244 0 0 jfet04 l=1.2 w=48.0
j805 0 244 260 0 jfet04 l=1.2 w=48.0
j806 261 243 0 0 jfet04 l=1.2 w=48.0
j807 0 243 261 0 jfet04 l=1.2 w=48.0
j808 262 261 0 0 jfet04 l=1.2 w=48.0
j809 0 261 262 0 jfet04 l=1.2 w=48.0
j810 262 260 0 0 jfet04 l=1.2 w=48.0
j811 0 260 262 0 jfet04 l=1.2 w=48.0
j812 262 259 0 0 jfet04 l=1.2 w=48.0
j813 0 259 262 0 jfet04 l=1.2 w=48.0

j814 262 258 0 0 jfet04 l=1.2 w=48.0
j815 0 258 262 0 jfet04 l=1.2 w=48.0
j816 263 262 0 0 jfet04 l=1.2 w=48.0
j817 0 262 263 0 jfet04 l=1.2 w=48.0
j818 184 264 184 248 dio16 l=1.2 w=20.0
j819 265 184 265 248 dio16 l=1.2 w=10.0
j820 248 248 266 0 jfet20 l=3.2 w=3.2
j821 266 267 266 248 dio16 l=1.2 w=4.0
j822 242 242 1 0 jfet16 l=1.2 w=6.0
j823 1 254 254 0 jfet16 l=1.2 w=6.0
j824 255 255 1 0 jfet16 l=1.2 w=6.0
j825 1 256 256 0 jfet16 l=1.2 w=6.0
j826 257 257 1 0 jfet16 l=1.2 w=6.0
j827 267 263 1 0 jfet04 l=1.2 w=20.0
j828 264 268 264 248 dio16 l=1.2 w=20.0
j829 248 248 184 0 jfet16 l=1.2 w=12.0
j830 269 265 269 248 dio16 l=1.2 w=10.0
j831 190 190 1 0 jfet16 l=1.2 w=6.0
j832 1 258 258 0 jfet16 l=1.2 w=6.0
j833 259 259 1 0 jfet16 l=1.2 w=6.0
j834 1 260 260 0 jfet16 l=1.2 w=6.0
j835 261 261 1 0 jfet16 l=1.2 w=6.0
j836 262 262 1 0 jfet16 l=1.2 w=6.0
j837 263 263 1 0 jfet16 l=1.2 w=6.0
j838 270 270 1 0 jfet16 l=1.2 w=3.2
j839 0 266 270 0 jfet16 l=1.2 w=10.0
j840 268 270 1 0 jfet16 l=1.2 w=20.0
j841 271 269 271 248 dio16 l=1.2 w=10.0
j842 248 271 248 248 dio16 l=1.2 w=10.0
j843 1 272 272 0 jfet16 l=1.2 w=6.0
j844 273 273 1 0 jfet16 l=1.2 w=6.0
j845 1 274 274 0 jfet16 l=1.2 w=6.0
j846 275 275 1 0 jfet16 l=1.2 w=6.0
j847 1 276 276 0 jfet16 l=1.2 w=6.0
j848 1 277 277 0 jfet16 l=1.2 w=6.0
j849 278 278 1 0 jfet16 l=1.2 w=6.0
j850 1 279 279 0 jfet16 l=1.2 w=6.0
j851 280 280 1 0 jfet16 l=1.2 w=6.0
j852 1 281 281 0 jfet16 l=1.2 w=6.0
j853 1 282 282 0 jfet16 l=1.2 w=6.0
j854 283 283 1 0 jfet16 l=1.2 w=6.0
j855 1 284 284 0 jfet16 l=1.2 w=6.0
j856 285 285 1 0 jfet16 l=1.2 w=6.0
j857 1 286 286 0 jfet16 l=1.2 w=6.0
j858 1 287 287 0 jfet16 l=1.2 w=6.0
j859 288 288 1 0 jfet16 l=1.2 w=6.0
j860 1 289 289 0 jfet16 l=1.2 w=6.0
j861 290 290 1 0 jfet16 l=1.2 w=6.0
j862 1 291 291 0 jfet16 l=1.2 w=6.0
j863 1 292 292 0 jfet16 l=1.2 w=48.0
j864 1 293 293 0 jfet16 l=1.2 w=48.0

j865 1 294 294 0 jfet16 l=1.2 w=48.0
j866 1 295 295 0 jfet16 l=1.2 w=9.2
j867 0 296 295 0 jfet04 l=1.2 w=38.0
j868 295 296 0 0 jfet04 l=1.2 w=38.0
j869 0 296 295 0 jfet04 l=1.2 w=38.0
j870 295 297 0 0 jfet04 l=1.2 w=38.0
j871 0 297 295 0 jfet04 l=1.2 w=38.0
j872 295 297 0 0 jfet04 l=1.2 w=38.0
j873 298 295 1 0 jfet04 l=1.2 w=38.0
j874 1 295 298 0 jfet04 l=1.2 w=38.0
j875 298 295 1 0 jfet04 l=1.2 w=38.0
j876 0 296 298 0 jfet04 l=1.2 w=38.0
j877 298 296 0 0 jfet04 l=1.2 w=38.0
j878 0 296 298 0 jfet04 l=1.2 w=38.0
j879 298 297 0 0 jfet04 l=1.2 w=38.0
j880 0 297 298 0 jfet04 l=1.2 w=38.0
j881 298 297 0 0 jfet04 l=1.2 w=38.0
j882 294 298 0 0 jfet04 l=1.2 w=64.0
j883 0 298 294 0 jfet04 l=1.2 w=64.0
j884 294 298 0 0 jfet04 l=1.2 w=64.0
j885 0 298 294 0 jfet04 l=1.2 w=64.0
j886 294 298 0 0 jfet04 l=1.2 w=64.0
j887 0 298 294 0 jfet04 l=1.2 w=64.0
j888 294 298 0 0 jfet04 l=1.2 w=64.0
j889 0 298 294 0 jfet04 l=1.2 w=64.0
j890 294 298 0 0 jfet04 l=1.2 w=64.0
j891 0 298 294 0 jfet04 l=1.2 w=64.0
j892 294 298 0 0 jfet04 l=1.2 w=64.0
j893 0 298 294 0 jfet04 l=1.2 w=64.0
j894 299 294 1 0 jfet04 l=1.2 w=64.0
j895 1 294 299 0 jfet04 l=1.2 w=64.0
j896 299 294 1 0 jfet04 l=1.2 w=64.0
j897 1 294 299 0 jfet04 l=1.2 w=64.0
j898 299 294 1 0 jfet04 l=1.2 w=64.0
j899 1 294 299 0 jfet04 l=1.2 w=64.0
j900 299 294 1 0 jfet04 l=1.2 w=64.0
j901 1 294 299 0 jfet04 l=1.2 w=64.0
j902 299 294 1 0 jfet04 l=1.2 w=64.0
j903 1 294 299 0 jfet04 l=1.2 w=64.0
j904 299 294 1 0 jfet04 l=1.2 w=64.0
j905 1 294 299 0 jfet04 l=1.2 w=64.0
j906 299 298 0 0 jfet04 l=1.2 w=64.0
j907 0 298 299 0 jfet04 l=1.2 w=64.0
j908 299 298 0 0 jfet04 l=1.2 w=64.0
j909 0 298 299 0 jfet04 l=1.2 w=64.0
j910 299 298 0 0 jfet04 l=1.2 w=64.0
j911 0 298 299 0 jfet04 l=1.2 w=64.0
j912 299 298 0 0 jfet04 l=1.2 w=64.0
j913 0 298 299 0 jfet04 l=1.2 w=64.0
j914 299 298 0 0 jfet04 l=1.2 w=64.0
j915 0 298 299 0 jfet04 l=1.2 w=64.0

j916 299 298 0 0 jfet04 l=1.2 w=64.0
j917 0 298 299 0 jfet04 l=1.2 w=64.0
j918 293 299 0 0 jfet04 l=1.2 w=64.0
j919 0 299 293 0 jfet04 l=1.2 w=64.0
j920 293 299 0 0 jfet04 l=1.2 w=64.0
j921 0 299 293 0 jfet04 l=1.2 w=64.0
j922 293 299 0 0 jfet04 l=1.2 w=64.0
j923 0 299 293 0 jfet04 l=1.2 w=64.0
j924 293 299 0 0 jfet04 l=1.2 w=64.0
j925 0 299 293 0 jfet04 l=1.2 w=64.0
j926 293 299 0 0 jfet04 l=1.2 w=64.0
j927 0 299 293 0 jfet04 l=1.2 w=64.0
j928 293 299 0 0 jfet04 l=1.2 w=64.0
j929 0 299 293 0 jfet04 l=1.2 w=64.0
j930 243 293 1 0 jfet04 l=1.2 w=64.0
j931 1 293 243 0 jfet04 l=1.2 w=64.0
j932 243 293 1 0 jfet04 l=1.2 w=64.0
j933 1 293 243 0 jfet04 l=1.2 w=64.0
j934 243 293 1 0 jfet04 l=1.2 w=64.0
j935 1 293 243 0 jfet04 l=1.2 w=64.0
j936 243 293 1 0 jfet04 l=1.2 w=64.0
j937 1 293 243 0 jfet04 l=1.2 w=64.0
j938 243 293 1 0 jfet04 l=1.2 w=64.0
j939 1 293 243 0 jfet04 l=1.2 w=64.0
j940 243 293 1 0 jfet04 l=1.2 w=64.0
j941 1 293 243 0 jfet04 l=1.2 w=64.0
j942 243 299 0 0 jfet04 l=1.2 w=64.0
j943 0 299 243 0 jfet04 l=1.2 w=64.0
j944 243 299 0 0 jfet04 l=1.2 w=64.0
j945 0 299 243 0 jfet04 l=1.2 w=64.0
j946 243 299 0 0 jfet04 l=1.2 w=64.0
j947 0 299 243 0 jfet04 l=1.2 w=64.0
j948 243 299 0 0 jfet04 l=1.2 w=64.0
j949 0 299 243 0 jfet04 l=1.2 w=64.0
j950 243 299 0 0 jfet04 l=1.2 w=64.0
j951 0 299 243 0 jfet04 l=1.2 w=64.0
j952 243 299 0 0 jfet04 l=1.2 w=64.0
j953 0 299 243 0 jfet04 l=1.2 w=64.0
j954 1 300 300 0 jfet16 l=1.2 w=48.0
j955 1 301 301 0 jfet16 l=1.2 w=16.0
j956 301 296 0 0 jfet04 l=1.2 w=64.0
j957 0 296 301 0 jfet04 l=1.2 w=64.0
j958 301 296 0 0 jfet04 l=1.2 w=64.0
j959 0 296 301 0 jfet04 l=1.2 w=64.0
j960 302 301 1 0 jfet04 l=1.2 w=64.0
j961 1 301 302 0 jfet04 l=1.2 w=64.0
j962 302 301 1 0 jfet04 l=1.2 w=64.0
j963 1 301 302 0 jfet04 l=1.2 w=64.0
j964 302 301 1 0 jfet04 l=1.2 w=64.0
j965 1 301 302 0 jfet04 l=1.2 w=64.0
j966 302 296 0 0 jfet04 l=1.2 w=64.0

j967 0 296 302 0 jfet04 l=1.2 w=64.0
j968 302 296 0 0 jfet04 l=1.2 w=64.0
j969 0 296 302 0 jfet04 l=1.2 w=64.0
j970 302 296 0 0 jfet04 l=1.2 w=64.0
j971 0 296 302 0 jfet04 l=1.2 w=64.0
j972 1 303 303 0 jfet16 l=1.2 w=9.2
j973 0 243 303 0 jfet04 l=1.2 w=38.0
j974 303 243 0 0 jfet04 l=1.2 w=38.0
j975 0 243 303 0 jfet04 l=1.2 w=38.0
j976 303 302 0 0 jfet04 l=1.2 w=38.0
j977 0 302 303 0 jfet04 l=1.2 w=38.0
j978 303 302 0 0 jfet04 l=1.2 w=38.0
j979 304 303 1 0 jfet04 l=1.2 w=38.0
j980 1 303 304 0 jfet04 l=1.2 w=38.0
j981 304 303 1 0 jfet04 l=1.2 w=38.0
j982 0 243 304 0 jfet04 l=1.2 w=38.0
j983 304 243 0 0 jfet04 l=1.2 w=38.0
j984 0 243 304 0 jfet04 l=1.2 w=38.0
j985 304 302 0 0 jfet04 l=1.2 w=38.0
j986 0 302 304 0 jfet04 l=1.2 w=38.0
j987 304 302 0 0 jfet04 l=1.2 w=38.0
j988 300 304 0 0 jfet04 l=1.2 w=64.0
j989 0 304 300 0 jfet04 l=1.2 w=64.0
j990 300 304 0 0 jfet04 l=1.2 w=64.0
j991 0 304 300 0 jfet04 l=1.2 w=64.0
j992 300 304 0 0 jfet04 l=1.2 w=64.0
j993 0 304 300 0 jfet04 l=1.2 w=64.0
j994 300 304 0 0 jfet04 l=1.2 w=64.0
j995 0 304 300 0 jfet04 l=1.2 w=64.0
j996 300 304 0 0 jfet04 l=1.2 w=64.0
j997 0 304 300 0 jfet04 l=1.2 w=64.0
j998 300 304 0 0 jfet04 l=1.2 w=64.0
j999 0 304 300 0 jfet04 l=1.2 w=64.0
j1000 305 300 1 0 jfet04 l=1.2 w=64.0
j1001 1 300 305 0 jfet04 l=1.2 w=64.0
j1002 305 300 1 0 jfet04 l=1.2 w=64.0
j1003 1 300 305 0 jfet04 l=1.2 w=64.0
j1004 305 300 1 0 jfet04 l=1.2 w=64.0
j1005 1 300 305 0 jfet04 l=1.2 w=64.0
j1006 305 300 1 0 jfet04 l=1.2 w=64.0
j1007 1 300 305 0 jfet04 l=1.2 w=64.0
j1008 305 300 1 0 jfet04 l=1.2 w=64.0
j1009 1 300 305 0 jfet04 l=1.2 w=64.0
j1010 305 300 1 0 jfet04 l=1.2 w=64.0
j1011 1 300 305 0 jfet04 l=1.2 w=64.0
j1012 305 304 0 0 jfet04 l=1.2 w=64.0
j1013 0 304 305 0 jfet04 l=1.2 w=64.0
j1014 305 304 0 0 jfet04 l=1.2 w=64.0
j1015 0 304 305 0 jfet04 l=1.2 w=64.0
j1016 305 304 0 0 jfet04 l=1.2 w=64.0
j1017 0 304 305 0 jfet04 l=1.2 w=64.0

j1018 305 304 0 0 jfet04 l=1.2 w=64.0
j1019 0 304 305 0 jfet04 l=1.2 w=64.0
j1020 305 304 0 0 jfet04 l=1.2 w=64.0
j1021 0 304 305 0 jfet04 l=1.2 w=64.0
j1022 305 304 0 0 jfet04 l=1.2 w=64.0
j1023 0 304 305 0 jfet04 l=1.2 w=64.0
j1024 292 305 0 0 jfet04 l=1.2 w=64.0
j1025 0 305 292 0 jfet04 l=1.2 w=64.0
j1026 292 305 0 0 jfet04 l=1.2 w=64.0
j1027 0 305 292 0 jfet04 l=1.2 w=64.0
j1028 292 305 0 0 jfet04 l=1.2 w=64.0
j1029 0 305 292 0 jfet04 l=1.2 w=64.0
j1030 292 305 0 0 jfet04 l=1.2 w=64.0
j1031 0 305 292 0 jfet04 l=1.2 w=64.0
j1032 292 305 0 0 jfet04 l=1.2 w=64.0
j1033 0 305 292 0 jfet04 l=1.2 w=64.0
j1034 292 305 0 0 jfet04 l=1.2 w=64.0
j1035 0 305 292 0 jfet04 l=1.2 w=64.0
j1036 297 292 1 0 jfet04 l=1.2 w=64.0
j1037 1 292 297 0 jfet04 l=1.2 w=64.0
j1038 297 292 1 0 jfet04 l=1.2 w=64.0
j1039 1 292 297 0 jfet04 l=1.2 w=64.0
j1040 297 292 1 0 jfet04 l=1.2 w=64.0
j1041 1 292 297 0 jfet04 l=1.2 w=64.0
j1042 297 292 1 0 jfet04 l=1.2 w=64.0
j1043 1 292 297 0 jfet04 l=1.2 w=64.0
j1044 297 292 1 0 jfet04 l=1.2 w=64.0
j1045 1 292 297 0 jfet04 l=1.2 w=64.0
j1046 297 292 1 0 jfet04 l=1.2 w=64.0
j1047 1 292 297 0 jfet04 l=1.2 w=64.0
j1048 297 305 0 0 jfet04 l=1.2 w=64.0
j1049 0 305 297 0 jfet04 l=1.2 w=64.0
j1050 297 305 0 0 jfet04 l=1.2 w=64.0
j1051 0 305 297 0 jfet04 l=1.2 w=64.0
j1052 297 305 0 0 jfet04 l=1.2 w=64.0
j1053 0 305 297 0 jfet04 l=1.2 w=64.0
j1054 297 305 0 0 jfet04 l=1.2 w=64.0
j1055 0 305 297 0 jfet04 l=1.2 w=64.0
j1056 297 305 0 0 jfet04 l=1.2 w=64.0
j1057 0 305 297 0 jfet04 l=1.2 w=64.0
j1058 297 305 0 0 jfet04 l=1.2 w=64.0
j1059 0 305 297 0 jfet04 l=1.2 w=64.0
j1060 272 306 0 0 jfet04 l=1.2 w=48.0
j1061 0 306 272 0 jfet04 l=1.2 w=48.0
j1062 273 169 0 0 jfet04 l=1.2 w=48.0
j1063 0 169 273 0 jfet04 l=1.2 w=48.0
j1064 274 307 0 0 jfet04 l=1.2 w=48.0
j1065 0 307 274 0 jfet04 l=1.2 w=48.0
j1066 275 308 0 0 jfet04 l=1.2 w=48.0
j1067 0 308 275 0 jfet04 l=1.2 w=48.0
j1068 276 275 0 0 jfet04 l=1.2 w=48.0

j1069 0 275 276 0 jfet04 l=1.2 w=48.0
j1070 276 274 0 0 jfet04 l=1.2 w=48.0
j1071 0 274 276 0 jfet04 l=1.2 w=48.0
j1072 276 273 0 0 jfet04 l=1.2 w=48.0
j1073 0 273 276 0 jfet04 l=1.2 w=48.0
j1074 276 272 0 0 jfet04 l=1.2 w=48.0
j1075 0 272 276 0 jfet04 l=1.2 w=48.0
j1076 277 309 0 0 jfet04 l=1.2 w=48.0
j1077 0 309 277 0 jfet04 l=1.2 w=48.0
j1078 278 310 0 0 jfet04 l=1.2 w=48.0
j1079 0 310 278 0 jfet04 l=1.2 w=48.0
j1080 279 311 0 0 jfet04 l=1.2 w=48.0
j1081 0 311 279 0 jfet04 l=1.2 w=48.0
j1082 280 175 0 0 jfet04 l=1.2 w=48.0
j1083 0 175 280 0 jfet04 l=1.2 w=48.0
j1084 281 280 0 0 jfet04 l=1.2 w=48.0
j1085 0 280 281 0 jfet04 l=1.2 w=48.0
j1086 281 279 0 0 jfet04 l=1.2 w=48.0
j1087 0 279 281 0 jfet04 l=1.2 w=48.0
j1088 281 278 0 0 jfet04 l=1.2 w=48.0
j1089 0 278 281 0 jfet04 l=1.2 w=48.0
j1090 281 277 0 0 jfet04 l=1.2 w=48.0
j1091 0 277 281 0 jfet04 l=1.2 w=48.0
j1092 282 306 0 0 jfet04 l=1.2 w=48.0
j1093 0 306 282 0 jfet04 l=1.2 w=48.0
j1094 283 311 0 0 jfet04 l=1.2 w=48.0
j1095 0 311 283 0 jfet04 l=1.2 w=48.0
j1096 284 175 0 0 jfet04 l=1.2 w=48.0
j1097 0 175 284 0 jfet04 l=1.2 w=48.0
j1098 285 309 0 0 jfet04 l=1.2 w=48.0
j1099 0 309 285 0 jfet04 l=1.2 w=48.0
j1100 286 285 0 0 jfet04 l=1.2 w=48.0
j1101 0 285 286 0 jfet04 l=1.2 w=48.0
j1102 286 284 0 0 jfet04 l=1.2 w=48.0
j1103 0 284 286 0 jfet04 l=1.2 w=48.0
j1104 286 283 0 0 jfet04 l=1.2 w=48.0
j1105 0 283 286 0 jfet04 l=1.2 w=48.0
j1106 286 282 0 0 jfet04 l=1.2 w=48.0
j1107 0 282 286 0 jfet04 l=1.2 w=48.0
j1108 287 306 0 0 jfet04 l=1.2 w=48.0
j1109 0 306 287 0 jfet04 l=1.2 w=48.0
j1110 288 311 0 0 jfet04 l=1.2 w=48.0
j1111 0 311 288 0 jfet04 l=1.2 w=48.0
j1112 289 169 0 0 jfet04 l=1.2 w=48.0
j1113 0 169 289 0 jfet04 l=1.2 w=48.0
j1114 290 308 0 0 jfet04 l=1.2 w=48.0
j1115 0 308 290 0 jfet04 l=1.2 w=48.0
j1116 291 290 0 0 jfet04 l=1.2 w=48.0
j1117 0 290 291 0 jfet04 l=1.2 w=48.0
j1118 291 289 0 0 jfet04 l=1.2 w=48.0
j1119 0 289 291 0 jfet04 l=1.2 w=48.0

j1120 291 288 0 0 jfet04 l=1.2 w=48.0
j1121 0 288 291 0 jfet04 l=1.2 w=48.0
j1122 291 287 0 0 jfet04 l=1.2 w=48.0
j1123 0 287 291 0 jfet04 l=1.2 w=48.0
j1124 176 177 312 0 jfet16 l=1.2 w=3.2
j1125 306 179 313 0 jfet16 l=1.2 w=8.0
j1126 314 182 306 0 jfet16 l=1.2 w=8.0
j1127 312 183 306 0 jfet16 l=1.2 w=8.0
j1128 1 315 306 0 jfet16 l=1.2 w=62.0
j1129 185 177 306 0 jfet16 l=1.2 w=6.0
j1130 316 187 306 0 jfet16 l=1.2 w=8.0
j1131 306 315 1 0 jfet16 l=1.2 w=62.0
j1132 306 188 317 0 jfet16 l=1.2 w=8.0
j1133 1 315 306 0 jfet16 l=1.2 w=62.0
j1134 306 318 0 0 jfet04 l=1.2 w=6.0
j1135 306 311 0 0 jfet04 l=1.2 w=70.0
j1136 0 311 306 0 jfet04 l=1.2 w=70.0
j1137 1 191 306 0 jfet16 l=1.2 w=9.2
j1138 306 311 0 0 jfet04 l=1.2 w=70.0
j1139 306 177 311 0 jfet16 l=1.2 w=17.2
j1140 0 306 311 0 jfet04 l=1.2 w=70.0
j1141 311 306 0 0 jfet04 l=1.2 w=70.0
j1142 319 299 0 0 jfet04 l=1.2 w=64.0
j1143 0 299 319 0 jfet04 l=1.2 w=64.0
j1144 319 299 0 0 jfet04 l=1.2 w=64.0
j1145 0 299 319 0 jfet04 l=1.2 w=64.0
j1146 319 299 0 0 jfet04 l=1.2 w=64.0
j1147 0 299 319 0 jfet04 l=1.2 w=64.0
j1148 319 299 0 0 jfet04 l=1.2 w=64.0
j1149 0 299 319 0 jfet04 l=1.2 w=64.0
j1150 319 299 0 0 jfet04 l=1.2 w=64.0
j1151 0 299 319 0 jfet04 l=1.2 w=64.0
j1152 319 299 0 0 jfet04 l=1.2 w=64.0
j1153 0 299 319 0 jfet04 l=1.2 w=64.0
j1154 243 319 1 0 jfet04 l=1.2 w=64.0
j1155 1 319 243 0 jfet04 l=1.2 w=64.0
j1156 243 319 1 0 jfet04 l=1.2 w=64.0
j1157 1 319 243 0 jfet04 l=1.2 w=64.0
j1158 243 319 1 0 jfet04 l=1.2 w=64.0
j1159 1 319 243 0 jfet04 l=1.2 w=64.0
j1160 243 319 1 0 jfet04 l=1.2 w=64.0
j1161 1 319 243 0 jfet04 l=1.2 w=64.0
j1162 243 319 1 0 jfet04 l=1.2 w=64.0
j1163 1 319 243 0 jfet04 l=1.2 w=64.0
j1164 243 319 1 0 jfet04 l=1.2 w=64.0
j1165 1 319 243 0 jfet04 l=1.2 w=64.0
j1166 243 299 0 0 jfet04 l=1.2 w=64.0
j1167 0 299 243 0 jfet04 l=1.2 w=64.0
j1168 243 299 0 0 jfet04 l=1.2 w=64.0
j1169 0 299 243 0 jfet04 l=1.2 w=64.0
j1170 243 299 0 0 jfet04 l=1.2 w=64.0

j1171 0 299 243 0 jfet04 l=1.2 w=64.0
j1172 243 299 0 0 jfet04 l=1.2 w=64.0
j1173 0 299 243 0 jfet04 l=1.2 w=64.0
j1174 243 299 0 0 jfet04 l=1.2 w=64.0
j1175 0 299 243 0 jfet04 l=1.2 w=64.0
j1176 243 299 0 0 jfet04 l=1.2 w=64.0
j1177 0 299 243 0 jfet04 l=1.2 w=64.0
j1178 319 319 1 0 jfet16 l=1.2 w=48.0
j1179 320 320 1 0 jfet20 l=3.2 w=40.0
j1180 0 243 320 0 jfet04 l=1.2 w=60.0
j1181 320 243 0 0 jfet04 l=1.2 w=60.0
j1182 0 243 320 0 jfet04 l=1.2 w=60.0
j1183 320 243 0 0 jfet04 l=1.2 w=60.0
j1184 321 321 1 0 jfet20 l=3.2 w=40.0
j1185 0 320 321 0 jfet04 l=1.2 w=60.0
j1186 321 320 0 0 jfet04 l=1.2 w=60.0
j1187 0 320 321 0 jfet04 l=1.2 w=60.0
j1188 321 320 0 0 jfet04 l=1.2 w=60.0
j1189 322 322 1 0 jfet20 l=3.2 w=40.0
j1190 0 243 322 0 jfet04 l=1.2 w=60.0
j1191 322 243 0 0 jfet04 l=1.2 w=60.0
j1192 0 243 322 0 jfet04 l=1.2 w=60.0
j1193 322 243 0 0 jfet04 l=1.2 w=60.0
j1194 323 323 1 0 jfet20 l=3.2 w=40.0
j1195 0 321 323 0 jfet04 l=1.2 w=60.0
j1196 323 321 0 0 jfet04 l=1.2 w=60.0
j1197 0 321 323 0 jfet04 l=1.2 w=60.0
j1198 323 321 0 0 jfet04 l=1.2 w=60.0
j1199 0 322 324 0 jfet04 l=1.2 w=45.2
j1200 324 322 0 0 jfet04 l=1.2 w=45.2
j1201 0 322 324 0 jfet04 l=1.2 w=45.2
j1202 324 322 0 0 jfet04 l=1.2 w=45.2
j1203 0 323 324 0 jfet04 l=1.2 w=45.2
j1204 324 323 0 0 jfet04 l=1.2 w=45.2
j1205 0 323 324 0 jfet04 l=1.2 w=45.2
j1206 324 323 0 0 jfet04 l=1.2 w=45.2
j1207 325 324 1 0 jfet04 l=1.2 w=56.0
j1208 1 324 325 0 jfet04 l=1.2 w=56.0
j1209 325 324 1 0 jfet04 l=1.2 w=56.0
j1210 1 324 325 0 jfet04 l=1.2 w=56.0
j1211 325 323 0 0 jfet04 l=1.2 w=56.0
j1212 0 323 325 0 jfet04 l=1.2 w=56.0
j1213 325 323 0 0 jfet04 l=1.2 w=56.0
j1214 0 323 325 0 jfet04 l=1.2 w=56.0
j1215 325 322 0 0 jfet04 l=1.2 w=56.0
j1216 0 322 325 0 jfet04 l=1.2 w=56.0
j1217 325 322 0 0 jfet04 l=1.2 w=56.0
j1218 0 322 325 0 jfet04 l=1.2 w=56.0
j1219 326 325 0 0 jfet04 l=1.2 w=48.0
j1220 0 325 326 0 jfet04 l=1.2 w=48.0
j1221 191 327 191 248 dio16 l=1.2 w=20.0

j1222 328 305 0 0 jfet04 l=1.2 w=64.0
j1223 0 305 328 0 jfet04 l=1.2 w=64.0
j1224 328 305 0 0 jfet04 l=1.2 w=64.0
j1225 0 305 328 0 jfet04 l=1.2 w=64.0
j1226 328 305 0 0 jfet04 l=1.2 w=64.0
j1227 0 305 328 0 jfet04 l=1.2 w=64.0
j1228 328 305 0 0 jfet04 l=1.2 w=64.0
j1229 0 305 328 0 jfet04 l=1.2 w=64.0
j1230 328 305 0 0 jfet04 l=1.2 w=64.0
j1231 0 305 328 0 jfet04 l=1.2 w=64.0
j1232 328 305 0 0 jfet04 l=1.2 w=64.0
j1233 0 305 328 0 jfet04 l=1.2 w=64.0
j1234 297 328 1 0 jfet04 l=1.2 w=64.0
j1235 1 328 297 0 jfet04 l=1.2 w=64.0
j1236 297 328 1 0 jfet04 l=1.2 w=64.0
j1237 1 328 297 0 jfet04 l=1.2 w=64.0
j1238 297 328 1 0 jfet04 l=1.2 w=64.0
j1239 1 328 297 0 jfet04 l=1.2 w=64.0
j1240 297 328 1 0 jfet04 l=1.2 w=64.0
j1241 1 328 297 0 jfet04 l=1.2 w=64.0
j1242 297 328 1 0 jfet04 l=1.2 w=64.0
j1243 1 328 297 0 jfet04 l=1.2 w=64.0
j1244 297 328 1 0 jfet04 l=1.2 w=64.0
j1245 1 328 297 0 jfet04 l=1.2 w=64.0
j1246 297 305 0 0 jfet04 l=1.2 w=64.0
j1247 0 305 297 0 jfet04 l=1.2 w=64.0
j1248 297 305 0 0 jfet04 l=1.2 w=64.0
j1249 0 305 297 0 jfet04 l=1.2 w=64.0
j1250 297 305 0 0 jfet04 l=1.2 w=64.0
j1251 0 305 297 0 jfet04 l=1.2 w=64.0
j1252 297 305 0 0 jfet04 l=1.2 w=64.0
j1253 0 305 297 0 jfet04 l=1.2 w=64.0
j1254 297 305 0 0 jfet04 l=1.2 w=64.0
j1255 0 305 297 0 jfet04 l=1.2 w=64.0
j1256 297 305 0 0 jfet04 l=1.2 w=64.0
j1257 0 305 297 0 jfet04 l=1.2 w=64.0
j1258 1 191 311 0 jfet16 l=1.2 w=9.2
j1259 0 329 311 0 jfet04 l=1.2 w=6.0
j1260 0 306 311 0 jfet04 l=1.2 w=70.0
j1261 330 330 1 0 jfet16 l=1.2 w=6.0
j1262 331 331 1 0 jfet16 l=1.2 w=3.2
j1263 332 191 332 248 dio16 l=1.2 w=10.0
j1264 330 297 0 0 jfet04 l=1.2 w=48.0
j1265 0 297 330 0 jfet04 l=1.2 w=48.0
j1266 333 330 1 0 jfet04 l=1.2 w=20.0
j1267 0 334 331 0 jfet16 l=1.2 w=10.0
j1268 335 331 1 0 jfet16 l=1.2 w=20.0
j1269 248 336 248 248 dio16 l=1.2 w=10.0
j1270 337 194 311 0 jfet16 l=1.2 w=8.0
j1271 311 338 1 0 jfet16 l=1.2 w=62.0
j1272 339 276 0 0 jfet04 l=1.2 w=48.0

j1273 0 276 339 0 jfet04 l=1.2 w=48.0
j1274 339 281 0 0 jfet04 l=1.2 w=48.0
j1275 0 281 339 0 jfet04 l=1.2 w=48.0
j1276 339 286 0 0 jfet04 l=1.2 w=48.0
j1277 0 286 339 0 jfet04 l=1.2 w=48.0
j1278 339 291 0 0 jfet04 l=1.2 w=48.0
j1279 0 291 339 0 jfet04 l=1.2 w=48.0
j1280 340 339 0 0 jfet04 l=1.2 w=48.0
j1281 0 339 340 0 jfet04 l=1.2 w=48.0
j1282 310 306 0 0 jfet04 l=1.2 w=48.0
j1283 0 306 310 0 jfet04 l=1.2 w=48.0
j1284 307 311 0 0 jfet04 l=1.2 w=48.0
j1285 0 311 307 0 jfet04 l=1.2 w=48.0
j1286 308 175 0 0 jfet04 l=1.2 w=48.0
j1287 0 175 308 0 jfet04 l=1.2 w=48.0
j1288 309 169 0 0 jfet04 l=1.2 w=48.0
j1289 0 169 309 0 jfet04 l=1.2 w=48.0
j1290 341 169 0 0 jfet04 l=1.2 w=48.0
j1291 0 169 341 0 jfet04 l=1.2 w=48.0
j1292 341 175 0 0 jfet04 l=1.2 w=48.0
j1293 0 175 341 0 jfet04 l=1.2 w=48.0
j1294 342 341 0 0 jfet04 l=1.2 w=48.0
j1295 0 341 342 0 jfet04 l=1.2 w=48.0
j1296 343 342 0 0 jfet04 l=1.2 w=48.0
j1297 0 342 343 0 jfet04 l=1.2 w=48.0
j1298 344 202 0 0 jfet04 l=1.2 w=48.0
j1299 0 202 344 0 jfet04 l=1.2 w=48.0
j1300 345 343 0 0 jfet04 l=1.2 w=48.0
j1301 0 343 345 0 jfet04 l=1.2 w=48.0
j1302 345 344 0 0 jfet04 l=1.2 w=48.0
j1303 0 344 345 0 jfet04 l=1.2 w=48.0
j1304 346 340 0 0 jfet04 l=1.2 w=48.0
j1305 0 340 346 0 jfet04 l=1.2 w=48.0
j1306 311 205 347 0 jfet16 l=1.2 w=8.0
j1307 1 338 311 0 jfet16 l=1.2 w=62.0
j1308 334 333 334 248 dio16 l=1.2 w=4.0
j1309 334 248 248 0 jfet20 l=3.2 w=3.2
j1310 348 335 348 248 dio16 l=1.2 w=20.0
j1311 336 349 336 248 dio16 l=1.2 w=10.0
j1312 185 177 311 0 jfet16 l=1.2 w=6.0
j1313 1 339 339 0 jfet16 l=1.2 w=6.0
j1314 340 340 1 0 jfet16 l=1.2 w=6.0
j1315 1 310 310 0 jfet16 l=1.2 w=6.0
j1316 307 307 1 0 jfet16 l=1.2 w=6.0
j1317 1 308 308 0 jfet16 l=1.2 w=6.0
j1318 309 309 1 0 jfet16 l=1.2 w=6.0
j1319 1 341 341 0 jfet16 l=1.2 w=6.0
j1320 342 342 1 0 jfet16 l=1.2 w=6.0
j1321 1 343 343 0 jfet16 l=1.2 w=6.0
j1322 344 344 1 0 jfet16 l=1.2 w=6.0
j1323 1 345 345 0 jfet16 l=1.2 w=6.0

j1324 346 346 1 0 jfet16 l=1.2 w=6.0
j1325 350 340 0 0 jfet04 l=1.2 w=64.0
j1326 0 340 350 0 jfet04 l=1.2 w=64.0
j1327 350 340 0 0 jfet04 l=1.2 w=64.0
j1328 351 345 350 0 jfet04 l=1.2 w=64.0
j1329 350 345 351 0 jfet04 l=1.2 w=64.0
j1330 351 345 350 0 jfet04 l=1.2 w=64.0
j1331 352 351 133 0 jfet04 l=1.2 w=64.0
j1332 133 351 352 0 jfet04 l=1.2 w=64.0
j1333 352 351 133 0 jfet04 l=1.2 w=64.0
j1334 0 353 352 0 jfet04 l=1.2 w=64.0
j1335 352 353 0 0 jfet04 l=1.2 w=64.0
j1336 0 353 352 0 jfet04 l=1.2 w=64.0
j1337 354 345 0 0 jfet04 l=1.2 w=64.0
j1338 0 345 354 0 jfet04 l=1.2 w=64.0
j1339 354 345 0 0 jfet04 l=1.2 w=64.0
j1340 355 346 354 0 jfet04 l=1.2 w=64.0
j1341 354 346 355 0 jfet04 l=1.2 w=64.0
j1342 355 346 354 0 jfet04 l=1.2 w=64.0
j1343 356 355 353 0 jfet04 l=1.2 w=64.0
j1344 353 355 356 0 jfet04 l=1.2 w=64.0
j1345 356 355 353 0 jfet04 l=1.2 w=64.0
j1346 0 133 356 0 jfet04 l=1.2 w=64.0
j1347 356 133 0 0 jfet04 l=1.2 w=64.0
j1348 0 133 356 0 jfet04 l=1.2 w=64.0
j1349 311 338 1 0 jfet16 l=1.2 w=62.0
j1350 248 248 177 0 jfet16 l=1.2 w=12.0
j1351 349 357 349 248 dio16 l=1.2 w=10.0
j1352 311 214 358 0 jfet16 l=1.2 w=8.0
j1353 359 217 311 0 jfet16 l=1.2 w=8.0
j1354 360 219 311 0 jfet16 l=1.2 w=8.0
j1355 1 361 361 0 jfet16 l=1.2 w=6.0
j1356 1 362 362 0 jfet16 l=1.2 w=6.0
j1357 1 363 363 0 jfet16 l=1.2 w=6.0
j1358 1 364 364 0 jfet16 l=1.2 w=6.0
j1359 351 351 1 0 jfet16 l=1.2 w=6.0
j1360 133 133 1 0 jfet16 l=1.2 w=6.0
j1361 355 355 1 0 jfet16 l=1.2 w=6.0
j1362 353 353 1 0 jfet16 l=1.2 w=6.0
j1363 176 177 360 0 jfet16 l=1.2 w=3.2
j1364 177 348 177 248 dio16 l=1.2 w=20.0
j1365 357 177 357 248 dio16 l=1.2 w=10.0
j1366 365 365 1 0 jfet16 l=1.2 w=6.0
j1367 248 248 366 0 jfet20 l=3.2 w=3.2
j1368 366 367 366 248 dio16 l=1.2 w=4.0
j1369 367 326 1 0 jfet04 l=1.2 w=20.0
j1370 327 368 327 248 dio16 l=1.2 w=20.0
j1371 248 248 191 0 jfet16 l=1.2 w=12.0
j1372 369 332 369 248 dio16 l=1.2 w=10.0
j1373 328 328 1 0 jfet16 l=1.2 w=48.0
j1374 370 370 1 0 jfet16 l=1.2 w=3.2

j1375 0 366 370 0 jfet16 l=1.2 w=10.0
j1376 368 370 1 0 jfet16 l=1.2 w=20.0
j1377 371 369 371 248 dio16 l=1.2 w=10.0
j1378 248 371 248 248 dio16 l=1.2 w=10.0
j1379 365 372 0 0 jfet04 l=1.2 w=48.0
j1380 0 372 365 0 jfet04 l=1.2 w=48.0
j1381 373 372 0 0 jfet04 l=1.2 w=64.0
j1382 0 372 373 0 jfet04 l=1.2 w=64.0
j1383 373 372 0 0 jfet04 l=1.2 w=64.0
j1384 361 227 373 0 jfet04 l=1.2 w=64.0
j1385 373 227 361 0 jfet04 l=1.2 w=64.0
j1386 361 227 373 0 jfet04 l=1.2 w=64.0
j1387 374 361 362 0 jfet04 l=1.2 w=64.0
j1388 362 361 374 0 jfet04 l=1.2 w=64.0
j1389 374 361 362 0 jfet04 l=1.2 w=64.0
j1390 0 364 374 0 jfet04 l=1.2 w=64.0
j1391 374 364 0 0 jfet04 l=1.2 w=64.0
j1392 0 364 374 0 jfet04 l=1.2 w=64.0
j1393 375 227 0 0 jfet04 l=1.2 w=64.0
j1394 0 227 375 0 jfet04 l=1.2 w=64.0
j1395 375 227 0 0 jfet04 l=1.2 w=64.0
j1396 363 365 375 0 jfet04 l=1.2 w=64.0
j1397 375 365 363 0 jfet04 l=1.2 w=64.0
j1398 363 365 375 0 jfet04 l=1.2 w=64.0
j1399 376 363 364 0 jfet04 l=1.2 w=64.0
j1400 364 363 376 0 jfet04 l=1.2 w=64.0
j1401 376 363 364 0 jfet04 l=1.2 w=64.0
j1402 0 362 376 0 jfet04 l=1.2 w=64.0
j1403 376 362 0 0 jfet04 l=1.2 w=64.0
j1404 0 362 376 0 jfet04 l=1.2 w=64.0
j1405 1 377 377 0 jfet16 l=1.2 w=6.0
j1406 378 378 1 0 jfet16 l=1.2 w=6.0
j1407 1 379 379 0 jfet16 l=1.2 w=6.0
j1408 380 380 1 0 jfet16 l=1.2 w=6.0
j1409 1 329 329 0 jfet16 l=1.2 w=6.0
j1410 1 381 381 0 jfet16 l=1.2 w=6.0
j1411 382 382 1 0 jfet16 l=1.2 w=6.0
j1412 1 383 383 0 jfet16 l=1.2 w=6.0
j1413 384 384 1 0 jfet16 l=1.2 w=6.0
j1414 1 385 385 0 jfet16 l=1.2 w=6.0
j1415 386 386 1 0 jfet16 l=1.2 w=6.0
j1416 387 387 1 0 jfet16 l=1.2 w=3.2
j1417 377 388 0 0 jfet04 l=1.2 w=48.0
j1418 0 388 377 0 jfet04 l=1.2 w=48.0
j1419 378 364 0 0 jfet04 l=1.2 w=48.0
j1420 0 364 378 0 jfet04 l=1.2 w=48.0
j1421 379 243 0 0 jfet04 l=1.2 w=48.0
j1422 0 243 379 0 jfet04 l=1.2 w=48.0
j1423 380 244 0 0 jfet04 l=1.2 w=48.0
j1424 0 244 380 0 jfet04 l=1.2 w=48.0
j1425 329 380 0 0 jfet04 l=1.2 w=48.0

j1426 0 380 329 0 jfet04 l=1.2 w=48.0
j1427 329 379 0 0 jfet04 l=1.2 w=48.0
j1428 0 379 329 0 jfet04 l=1.2 w=48.0
j1429 329 378 0 0 jfet04 l=1.2 w=48.0
j1430 0 378 329 0 jfet04 l=1.2 w=48.0
j1431 329 377 0 0 jfet04 l=1.2 w=48.0
j1432 0 377 329 0 jfet04 l=1.2 w=48.0
j1433 381 388 0 0 jfet04 l=1.2 w=48.0
j1434 0 388 381 0 jfet04 l=1.2 w=48.0
j1435 382 362 0 0 jfet04 l=1.2 w=48.0
j1436 0 362 382 0 jfet04 l=1.2 w=48.0
j1437 383 244 0 0 jfet04 l=1.2 w=48.0
j1438 0 244 383 0 jfet04 l=1.2 w=48.0
j1439 384 243 0 0 jfet04 l=1.2 w=48.0
j1440 0 243 384 0 jfet04 l=1.2 w=48.0
j1441 385 384 0 0 jfet04 l=1.2 w=48.0
j1442 0 384 385 0 jfet04 l=1.2 w=48.0
j1443 385 383 0 0 jfet04 l=1.2 w=48.0
j1444 0 383 385 0 jfet04 l=1.2 w=48.0
j1445 385 382 0 0 jfet04 l=1.2 w=48.0
j1446 0 382 385 0 jfet04 l=1.2 w=48.0
j1447 385 381 0 0 jfet04 l=1.2 w=48.0
j1448 0 381 385 0 jfet04 l=1.2 w=48.0
j1449 386 385 0 0 jfet04 l=1.2 w=48.0
j1450 0 385 386 0 jfet04 l=1.2 w=48.0
j1451 389 386 1 0 jfet04 l=1.2 w=20.0
j1452 0 390 387 0 jfet16 l=1.2 w=10.0
j1453 391 387 1 0 jfet16 l=1.2 w=20.0
j1454 248 392 248 248 dio16 l=1.2 w=10.0
j1455 390 389 390 248 dio16 l=1.2 w=4.0
j1456 390 248 248 0 jfet20 l=3.2 w=3.2
j1457 393 391 393 248 dio16 l=1.2 w=20.0
j1458 392 394 392 248 dio16 l=1.2 w=10.0
j1459 248 248 338 0 jfet16 l=1.2 w=12.0
j1460 394 395 394 248 dio16 l=1.2 w=10.0
j1461 395 338 395 248 dio16 l=1.2 w=10.0
j1462 338 393 338 248 dio16 l=1.2 w=20.0
j1463 326 326 1 0 jfet16 l=1.2 w=6.0
j1464 324 324 1 0 jfet16 l=1.2 w=10.0
j1465 388 253 0 0 jfet04 l=1.2 w=48.0
j1466 0 253 388 0 jfet04 l=1.2 w=48.0
j1467 396 253 0 0 jfet04 l=1.2 w=48.0
j1468 0 253 396 0 jfet04 l=1.2 w=48.0
j1469 397 364 0 0 jfet04 l=1.2 w=48.0
j1470 0 364 397 0 jfet04 l=1.2 w=48.0
j1471 398 243 0 0 jfet04 l=1.2 w=48.0
j1472 0 243 398 0 jfet04 l=1.2 w=48.0
j1473 399 244 0 0 jfet04 l=1.2 w=48.0
j1474 0 244 399 0 jfet04 l=1.2 w=48.0
j1475 318 399 0 0 jfet04 l=1.2 w=48.0
j1476 0 399 318 0 jfet04 l=1.2 w=48.0

j1477 318 398 0 0 jfet04 l=1.2 w=48.0
j1478 0 398 318 0 jfet04 l=1.2 w=48.0
j1479 318 397 0 0 jfet04 l=1.2 w=48.0
j1480 0 397 318 0 jfet04 l=1.2 w=48.0
j1481 318 396 0 0 jfet04 l=1.2 w=48.0
j1482 0 396 318 0 jfet04 l=1.2 w=48.0
j1483 400 253 0 0 jfet04 l=1.2 w=48.0
j1484 0 253 400 0 jfet04 l=1.2 w=48.0
j1485 401 362 0 0 jfet04 l=1.2 w=48.0
j1486 0 362 401 0 jfet04 l=1.2 w=48.0
j1487 402 244 0 0 jfet04 l=1.2 w=48.0
j1488 0 244 402 0 jfet04 l=1.2 w=48.0
j1489 403 243 0 0 jfet04 l=1.2 w=48.0
j1490 0 243 403 0 jfet04 l=1.2 w=48.0
j1491 404 403 0 0 jfet04 l=1.2 w=48.0
j1492 0 403 404 0 jfet04 l=1.2 w=48.0
j1493 404 402 0 0 jfet04 l=1.2 w=48.0
j1494 0 402 404 0 jfet04 l=1.2 w=48.0
j1495 404 401 0 0 jfet04 l=1.2 w=48.0
j1496 0 401 404 0 jfet04 l=1.2 w=48.0
j1497 404 400 0 0 jfet04 l=1.2 w=48.0
j1498 0 400 404 0 jfet04 l=1.2 w=48.0
j1499 405 404 0 0 jfet04 l=1.2 w=48.0
j1500 0 404 405 0 jfet04 l=1.2 w=48.0
j1501 315 406 315 248 dio16 l=1.2 w=20.0
j1502 407 315 407 248 dio16 l=1.2 w=10.0
j1503 248 248 408 0 jfet20 l=3.2 w=3.2
j1504 408 409 408 248 dio16 l=1.2 w=4.0
j1505 388 388 1 0 jfet16 l=1.2 w=6.0
j1506 1 396 396 0 jfet16 l=1.2 w=6.0
j1507 397 397 1 0 jfet16 l=1.2 w=6.0
j1508 1 398 398 0 jfet16 l=1.2 w=6.0
j1509 399 399 1 0 jfet16 l=1.2 w=6.0
j1510 409 405 1 0 jfet04 l=1.2 w=20.0
j1511 406 410 406 248 dio16 l=1.2 w=20.0
j1512 248 248 315 0 jfet16 l=1.2 w=12.0
j1513 411 407 411 248 dio16 l=1.2 w=10.0
j1514 318 318 1 0 jfet16 l=1.2 w=6.0
j1515 1 400 400 0 jfet16 l=1.2 w=6.0
j1516 401 401 1 0 jfet16 l=1.2 w=6.0
j1517 1 402 402 0 jfet16 l=1.2 w=6.0
j1518 403 403 1 0 jfet16 l=1.2 w=6.0
j1519 404 404 1 0 jfet16 l=1.2 w=6.0
j1520 405 405 1 0 jfet16 l=1.2 w=6.0
j1521 412 412 1 0 jfet16 l=1.2 w=3.2
j1522 0 408 412 0 jfet16 l=1.2 w=10.0
j1523 410 412 1 0 jfet16 l=1.2 w=20.0
j1524 413 411 413 248 dio16 l=1.2 w=10.0
j1525 248 413 248 248 dio16 l=1.2 w=10.0
j1526 1 414 414 0 jfet16 l=1.2 w=6.0
j1527 415 415 1 0 jfet16 l=1.2 w=6.0

j1528 1 416 416 0 jfet16 l=1.2 w=6.0
j1529 417 417 1 0 jfet16 l=1.2 w=6.0
j1530 1 418 418 0 jfet16 l=1.2 w=6.0
j1531 1 419 419 0 jfet16 l=1.2 w=6.0
j1532 420 420 1 0 jfet16 l=1.2 w=6.0
j1533 1 421 421 0 jfet16 l=1.2 w=6.0
j1534 422 422 1 0 jfet16 l=1.2 w=6.0
j1535 1 423 423 0 jfet16 l=1.2 w=6.0
j1536 1 424 424 0 jfet16 l=1.2 w=6.0
j1537 425 425 1 0 jfet16 l=1.2 w=6.0
j1538 1 426 426 0 jfet16 l=1.2 w=6.0
j1539 427 427 1 0 jfet16 l=1.2 w=6.0
j1540 1 428 428 0 jfet16 l=1.2 w=6.0
j1541 1 429 429 0 jfet16 l=1.2 w=6.0
j1542 430 430 1 0 jfet16 l=1.2 w=6.0
j1543 1 431 431 0 jfet16 l=1.2 w=6.0
j1544 432 432 1 0 jfet16 l=1.2 w=6.0
j1545 1 433 433 0 jfet16 l=1.2 w=6.0
j1546 1 434 434 0 jfet16 l=1.2 w=6.0
j1547 1 435 435 0 jfet16 l=1.2 w=3.2
j1548 1 436 436 0 jfet16 l=1.2 w=3.2
j1549 1 437 437 0 jfet16 l=1.2 w=3.2
j1550 438 438 1 0 jfet16 l=1.2 w=3.2
j1551 434 439 0 0 jfet04 l=1.2 w=48.0
j1552 0 439 434 0 jfet04 l=1.2 w=48.0
j1553 0 434 436 0 jfet04 l=1.2 w=48.0
j1554 440 434 0 0 jfet04 l=1.2 w=48.0
j1555 1 436 440 0 jfet04 l=1.2 w=48.0
j1556 0 441 437 0 jfet04 l=1.2 w=48.0
j1557 442 441 0 0 jfet04 l=1.2 w=48.0
j1558 1 437 442 0 jfet04 l=1.2 w=48.0
j1559 443 443 1 0 jfet16 l=1.2 w=6.0
j1560 444 444 1 0 jfet16 l=1.2 w=3.2
j1561 445 438 1 0 jfet04 l=1.2 w=48.0
j1562 0 243 445 0 jfet04 l=1.2 w=48.0
j1563 438 243 0 0 jfet04 l=1.2 w=48.0
j1564 435 445 0 0 jfet04 l=1.2 w=48.0
j1565 0 442 435 0 jfet04 l=1.2 w=48.0
j1566 435 440 0 0 jfet04 l=1.2 w=48.0
j1567 175 435 1 0 jfet04 l=1.2 w=48.0
j1568 0 440 175 0 jfet04 l=1.2 w=48.0
j1569 175 442 0 0 jfet04 l=1.2 w=48.0
j1570 0 445 175 0 jfet04 l=1.2 w=48.0
j1571 175 435 1 0 jfet04 l=1.2 w=48.0
j1572 0 440 175 0 jfet04 l=1.2 w=48.0
j1573 175 442 0 0 jfet04 l=1.2 w=48.0
j1574 0 445 175 0 jfet04 l=1.2 w=48.0
j1575 175 445 0 0 jfet04 l=1.2 w=48.0
j1576 0 442 175 0 jfet04 l=1.2 w=48.0
j1577 175 440 0 0 jfet04 l=1.2 w=48.0
j1578 1 435 175 0 jfet04 l=1.2 w=48.0

j1579 175 435 1 0 jfet04 l=1.2 w=48.0
j1580 0 440 175 0 jfet04 l=1.2 w=48.0
j1581 175 442 0 0 jfet04 l=1.2 w=48.0
j1582 0 445 175 0 jfet04 l=1.2 w=48.0
j1583 175 445 0 0 jfet04 l=1.2 w=48.0
j1584 0 442 175 0 jfet04 l=1.2 w=48.0
j1585 175 440 0 0 jfet04 l=1.2 w=48.0
j1586 1 435 175 0 jfet04 l=1.2 w=48.0
j1587 443 175 0 0 jfet04 l=1.2 w=48.0
j1588 0 175 443 0 jfet04 l=1.2 w=48.0
j1589 446 443 1 0 jfet04 l=1.2 w=20.0
j1590 0 447 444 0 jfet16 l=1.2 w=10.0
j1591 448 444 1 0 jfet16 l=1.2 w=20.0
j1592 248 449 248 248 dio16 l=1.2 w=10.0
j1593 414 450 0 0 jfet04 l=1.2 w=48.0
j1594 0 450 414 0 jfet04 l=1.2 w=48.0
j1595 415 169 0 0 jfet04 l=1.2 w=48.0
j1596 0 169 415 0 jfet04 l=1.2 w=48.0
j1597 416 451 0 0 jfet04 l=1.2 w=48.0
j1598 0 451 416 0 jfet04 l=1.2 w=48.0
j1599 417 452 0 0 jfet04 l=1.2 w=48.0
j1600 0 452 417 0 jfet04 l=1.2 w=48.0
j1601 418 417 0 0 jfet04 l=1.2 w=48.0
j1602 0 417 418 0 jfet04 l=1.2 w=48.0
j1603 418 416 0 0 jfet04 l=1.2 w=48.0
j1604 0 416 418 0 jfet04 l=1.2 w=48.0
j1605 418 415 0 0 jfet04 l=1.2 w=48.0
j1606 0 415 418 0 jfet04 l=1.2 w=48.0
j1607 418 414 0 0 jfet04 l=1.2 w=48.0
j1608 0 414 418 0 jfet04 l=1.2 w=48.0
j1609 419 453 0 0 jfet04 l=1.2 w=48.0
j1610 0 453 419 0 jfet04 l=1.2 w=48.0
j1611 420 454 0 0 jfet04 l=1.2 w=48.0
j1612 0 454 420 0 jfet04 l=1.2 w=48.0
j1613 421 455 0 0 jfet04 l=1.2 w=48.0
j1614 0 455 421 0 jfet04 l=1.2 w=48.0
j1615 422 175 0 0 jfet04 l=1.2 w=48.0
j1616 0 175 422 0 jfet04 l=1.2 w=48.0
j1617 423 422 0 0 jfet04 l=1.2 w=48.0
j1618 0 422 423 0 jfet04 l=1.2 w=48.0
j1619 423 421 0 0 jfet04 l=1.2 w=48.0
j1620 0 421 423 0 jfet04 l=1.2 w=48.0
j1621 423 420 0 0 jfet04 l=1.2 w=48.0
j1622 0 420 423 0 jfet04 l=1.2 w=48.0
j1623 423 419 0 0 jfet04 l=1.2 w=48.0
j1624 0 419 423 0 jfet04 l=1.2 w=48.0
j1625 424 450 0 0 jfet04 l=1.2 w=48.0
j1626 0 450 424 0 jfet04 l=1.2 w=48.0
j1627 425 455 0 0 jfet04 l=1.2 w=48.0
j1628 0 455 425 0 jfet04 l=1.2 w=48.0
j1629 426 175 0 0 jfet04 l=1.2 w=48.0

j1630 0 175 426 0 jfet04 l=1.2 w=48.0
j1631 427 453 0 0 jfet04 l=1.2 w=48.0
j1632 0 453 427 0 jfet04 l=1.2 w=48.0
j1633 428 427 0 0 jfet04 l=1.2 w=48.0
j1634 0 427 428 0 jfet04 l=1.2 w=48.0
j1635 428 426 0 0 jfet04 l=1.2 w=48.0
j1636 0 426 428 0 jfet04 l=1.2 w=48.0
j1637 428 425 0 0 jfet04 l=1.2 w=48.0
j1638 0 425 428 0 jfet04 l=1.2 w=48.0
j1639 428 424 0 0 jfet04 l=1.2 w=48.0
j1640 0 424 428 0 jfet04 l=1.2 w=48.0
j1641 429 450 0 0 jfet04 l=1.2 w=48.0
j1642 0 450 429 0 jfet04 l=1.2 w=48.0
j1643 430 455 0 0 jfet04 l=1.2 w=48.0
j1644 0 455 430 0 jfet04 l=1.2 w=48.0
j1645 431 169 0 0 jfet04 l=1.2 w=48.0
j1646 0 169 431 0 jfet04 l=1.2 w=48.0
j1647 432 452 0 0 jfet04 l=1.2 w=48.0
j1648 0 452 432 0 jfet04 l=1.2 w=48.0
j1649 433 432 0 0 jfet04 l=1.2 w=48.0
j1650 0 432 433 0 jfet04 l=1.2 w=48.0
j1651 433 431 0 0 jfet04 l=1.2 w=48.0
j1652 0 431 433 0 jfet04 l=1.2 w=48.0
j1653 433 430 0 0 jfet04 l=1.2 w=48.0
j1654 0 430 433 0 jfet04 l=1.2 w=48.0
j1655 433 429 0 0 jfet04 l=1.2 w=48.0
j1656 0 429 433 0 jfet04 l=1.2 w=48.0
j1657 447 446 447 248 dio16 l=1.2 w=4.0
j1658 447 248 248 0 jfet20 l=3.2 w=3.2
j1659 456 448 456 248 dio16 l=1.2 w=20.0
j1660 449 457 449 248 dio16 l=1.2 w=10.0
j1661 248 248 183 0 jfet16 l=1.2 w=12.0
j1662 457 458 457 248 dio16 l=1.2 w=10.0
j1663 176 177 459 0 jfet16 l=1.2 w=3.2
j1664 450 179 460 0 jfet16 l=1.2 w=8.0
j1665 461 182 450 0 jfet16 l=1.2 w=8.0
j1666 459 183 450 0 jfet16 l=1.2 w=8.0
j1667 458 183 458 248 dio16 l=1.2 w=10.0
j1668 1 462 450 0 jfet16 l=1.2 w=62.0
j1669 185 177 450 0 jfet16 l=1.2 w=6.0
j1670 183 456 183 248 dio16 l=1.2 w=20.0
j1671 463 187 450 0 jfet16 l=1.2 w=8.0
j1672 450 462 1 0 jfet16 l=1.2 w=62.0
j1673 450 188 464 0 jfet16 l=1.2 w=8.0
j1674 1 462 450 0 jfet16 l=1.2 w=62.0
j1675 465 466 0 0 jfet04 l=1.2 w=48.0
j1676 0 466 465 0 jfet04 l=1.2 w=48.0
j1677 0 467 468 0 jfet04 l=1.2 w=48.0
j1678 469 467 0 0 jfet04 l=1.2 w=48.0
j1679 1 468 469 0 jfet04 l=1.2 w=48.0
j1680 470 471 1 0 jfet04 l=1.2 w=48.0

j1681 0 472 470 0 jfet04 l=1.2 w=48.0
j1682 471 472 0 0 jfet04 l=1.2 w=48.0
j1683 0 473 474 0 jfet04 l=1.2 w=48.0
j1684 475 473 0 0 jfet04 l=1.2 w=48.0
j1685 1 474 475 0 jfet04 l=1.2 w=48.0
j1686 476 477 1 0 jfet04 l=1.2 w=48.0
j1687 0 465 476 0 jfet04 l=1.2 w=48.0
j1688 477 465 0 0 jfet04 l=1.2 w=48.0
j1689 0 469 478 0 jfet04 l=1.2 w=48.0
j1690 478 470 0 0 jfet04 l=1.2 w=48.0
j1691 0 475 478 0 jfet04 l=1.2 w=48.0
j1692 478 476 0 0 jfet04 l=1.2 w=48.0
j1693 479 478 1 0 jfet04 l=1.2 w=48.0
j1694 0 476 479 0 jfet04 l=1.2 w=48.0
j1695 479 475 0 0 jfet04 l=1.2 w=48.0
j1696 0 470 479 0 jfet04 l=1.2 w=48.0
j1697 479 469 0 0 jfet04 l=1.2 w=48.0
j1698 0 479 480 0 jfet04 l=1.2 w=48.0
j1699 481 479 0 0 jfet04 l=1.2 w=48.0
j1700 1 480 481 0 jfet04 l=1.2 w=48.0
j1701 1 468 468 0 jfet16 l=1.2 w=3.2
j1702 471 471 1 0 jfet16 l=1.2 w=3.2
j1703 1 474 474 0 jfet16 l=1.2 w=3.2
j1704 477 477 1 0 jfet16 l=1.2 w=3.2
j1705 450 482 0 0 jfet04 l=1.2 w=6.0
j1706 450 455 0 0 jfet04 l=1.2 w=70.0
j1707 0 455 450 0 jfet04 l=1.2 w=70.0
j1708 1 191 450 0 jfet16 l=1.2 w=9.2
j1709 450 455 0 0 jfet04 l=1.2 w=70.0
j1710 450 177 455 0 jfet16 l=1.2 w=17.2
j1711 0 450 455 0 jfet04 l=1.2 w=70.0
j1712 455 450 0 0 jfet04 l=1.2 w=70.0
j1713 465 465 1 0 jfet16 l=1.2 w=6.0
j1714 478 478 1 0 jfet16 l=1.2 w=3.2
j1715 1 480 480 0 jfet16 l=1.2 w=3.2
j1716 1 191 455 0 jfet16 l=1.2 w=9.2
j1717 0 483 455 0 jfet04 l=1.2 w=6.0
j1718 0 450 455 0 jfet04 l=1.2 w=70.0
j1719 1 484 484 0 jfet16 l=1.2 w=6.0
j1720 485 485 1 0 jfet16 l=1.2 w=6.0
j1721 1 486 486 0 jfet16 l=1.2 w=6.0
j1722 1 487 487 0 jfet16 l=1.2 w=6.0
j1723 488 488 1 0 jfet16 l=1.2 w=6.0
j1724 1 489 489 0 jfet16 l=1.2 w=6.0
j1725 1 490 490 0 jfet16 l=1.2 w=6.0
j1726 491 491 1 0 jfet16 l=1.2 w=6.0
j1727 492 492 1 0 jfet16 l=1.2 w=6.0
j1728 493 493 1 0 jfet16 l=1.2 w=6.0
j1729 494 494 1 0 jfet16 l=1.2 w=6.0
j1730 1 495 495 0 jfet16 l=1.2 w=6.0
j1731 496 496 1 0 jfet16 l=1.2 w=6.0

j1732 497 497 1 0 jfet16 l=1.2 w=6.0
j1733 498 498 1 0 jfet16 l=1.2 w=6.0
j1734 499 499 1 0 jfet16 l=1.2 w=6.0
j1735 1 500 500 0 jfet16 l=1.2 w=6.0
j1736 501 501 1 0 jfet16 l=1.2 w=6.0
j1737 502 502 1 0 jfet16 l=1.2 w=6.0
j1738 503 503 1 0 jfet16 l=1.2 w=6.0
j1739 1 504 504 0 jfet16 l=1.2 w=6.0
j1740 505 505 1 0 jfet16 l=1.2 w=6.0
j1741 506 194 455 0 jfet16 l=1.2 w=8.0
j1742 455 507 1 0 jfet16 l=1.2 w=62.0
j1743 1 508 508 0 jfet16 l=1.2 w=6.0
j1744 1 509 509 0 jfet16 l=1.2 w=6.0
j1745 1 510 510 0 jfet16 l=1.2 w=6.0
j1746 1 511 511 0 jfet16 l=1.2 w=6.0
j1747 484 472 0 0 jfet04 l=1.2 w=48.0
j1748 0 472 484 0 jfet04 l=1.2 w=48.0
j1749 485 481 0 0 jfet04 l=1.2 w=48.0
j1750 0 481 485 0 jfet04 l=1.2 w=48.0
j1751 486 484 0 0 jfet04 l=1.2 w=48.0
j1752 0 484 486 0 jfet04 l=1.2 w=48.0
j1753 486 485 0 0 jfet04 l=1.2 w=48.0
j1754 0 485 486 0 jfet04 l=1.2 w=48.0
j1755 487 512 0 0 jfet04 l=1.2 w=48.0
j1756 0 512 487 0 jfet04 l=1.2 w=48.0
j1757 488 513 0 0 jfet04 l=1.2 w=48.0
j1758 0 513 488 0 jfet04 l=1.2 w=48.0
j1759 489 487 0 0 jfet04 l=1.2 w=48.0
j1760 0 487 489 0 jfet04 l=1.2 w=48.0
j1761 489 488 0 0 jfet04 l=1.2 w=48.0
j1762 0 488 489 0 jfet04 l=1.2 w=48.0
j1763 490 489 0 0 jfet04 l=1.2 w=48.0
j1764 0 489 490 0 jfet04 l=1.2 w=48.0
j1765 490 486 0 0 jfet04 l=1.2 w=48.0
j1766 0 486 490 0 jfet04 l=1.2 w=48.0
j1767 491 490 0 0 jfet04 l=1.2 w=48.0
j1768 0 490 491 0 jfet04 l=1.2 w=48.0
j1769 492 491 0 0 jfet04 l=1.2 w=48.0
j1770 0 491 492 0 jfet04 l=1.2 w=48.0
j1771 493 481 0 0 jfet04 l=1.2 w=48.0
j1772 0 481 493 0 jfet04 l=1.2 w=48.0
j1773 494 514 0 0 jfet04 l=1.2 w=48.0
j1774 0 514 494 0 jfet04 l=1.2 w=48.0
j1775 495 494 0 0 jfet04 l=1.2 w=48.0
j1776 0 494 495 0 jfet04 l=1.2 w=48.0
j1777 495 493 0 0 jfet04 l=1.2 w=48.0
j1778 0 493 495 0 jfet04 l=1.2 w=48.0
j1779 495 492 0 0 jfet04 l=1.2 w=48.0
j1780 0 492 495 0 jfet04 l=1.2 w=48.0
j1781 496 495 0 0 jfet04 l=1.2 w=48.0
j1782 0 495 496 0 jfet04 l=1.2 w=48.0

j1783 497 481 0 0 jfet04 l=1.2 w=48.0
j1784 0 481 497 0 jfet04 l=1.2 w=48.0
j1785 498 505 0 0 jfet04 l=1.2 w=48.0
j1786 0 505 498 0 jfet04 l=1.2 w=48.0
j1787 499 297 0 0 jfet04 l=1.2 w=48.0
j1788 0 297 499 0 jfet04 l=1.2 w=48.0
j1789 500 499 0 0 jfet04 l=1.2 w=48.0
j1790 0 499 500 0 jfet04 l=1.2 w=48.0
j1791 500 498 0 0 jfet04 l=1.2 w=48.0
j1792 0 498 500 0 jfet04 l=1.2 w=48.0
j1793 500 497 0 0 jfet04 l=1.2 w=48.0
j1794 0 497 500 0 jfet04 l=1.2 w=48.0
j1795 501 500 0 0 jfet04 l=1.2 w=48.0
j1796 0 500 501 0 jfet04 l=1.2 w=48.0
j1797 502 501 0 0 jfet04 l=1.2 w=48.0
j1798 0 501 502 0 jfet04 l=1.2 w=48.0
j1799 503 496 0 0 jfet04 l=1.2 w=48.0
j1800 0 496 503 0 jfet04 l=1.2 w=48.0
j1801 504 503 0 0 jfet04 l=1.2 w=48.0
j1802 0 503 504 0 jfet04 l=1.2 w=48.0
j1803 504 502 0 0 jfet04 l=1.2 w=48.0
j1804 0 502 504 0 jfet04 l=1.2 w=48.0
j1805 505 504 0 0 jfet04 l=1.2 w=48.0
j1806 0 504 505 0 jfet04 l=1.2 w=48.0
j1807 515 418 0 0 jfet04 l=1.2 w=48.0
j1808 0 418 515 0 jfet04 l=1.2 w=48.0
j1809 515 423 0 0 jfet04 l=1.2 w=48.0
j1810 0 423 515 0 jfet04 l=1.2 w=48.0
j1811 515 428 0 0 jfet04 l=1.2 w=48.0
j1812 0 428 515 0 jfet04 l=1.2 w=48.0
j1813 515 433 0 0 jfet04 l=1.2 w=48.0
j1814 0 433 515 0 jfet04 l=1.2 w=48.0
j1815 516 515 0 0 jfet04 l=1.2 w=48.0
j1816 0 515 516 0 jfet04 l=1.2 w=48.0
j1817 454 450 0 0 jfet04 l=1.2 w=48.0
j1818 0 450 454 0 jfet04 l=1.2 w=48.0
j1819 451 455 0 0 jfet04 l=1.2 w=48.0
j1820 0 455 451 0 jfet04 l=1.2 w=48.0
j1821 452 175 0 0 jfet04 l=1.2 w=48.0
j1822 0 175 452 0 jfet04 l=1.2 w=48.0
j1823 453 169 0 0 jfet04 l=1.2 w=48.0
j1824 0 169 453 0 jfet04 l=1.2 w=48.0
j1825 517 169 0 0 jfet04 l=1.2 w=48.0
j1826 0 169 517 0 jfet04 l=1.2 w=48.0
j1827 517 175 0 0 jfet04 l=1.2 w=48.0
j1828 0 175 517 0 jfet04 l=1.2 w=48.0
j1829 518 517 0 0 jfet04 l=1.2 w=48.0
j1830 0 517 518 0 jfet04 l=1.2 w=48.0
j1831 519 518 0 0 jfet04 l=1.2 w=48.0
j1832 0 518 519 0 jfet04 l=1.2 w=48.0
j1833 520 202 0 0 jfet04 l=1.2 w=48.0

j1834 0 202 520 0 jfet04 l=1.2 w=48.0
j1835 521 519 0 0 jfet04 l=1.2 w=48.0
j1836 0 519 521 0 jfet04 l=1.2 w=48.0
j1837 521 520 0 0 jfet04 l=1.2 w=48.0
j1838 0 520 521 0 jfet04 l=1.2 w=48.0
j1839 522 516 0 0 jfet04 l=1.2 w=48.0
j1840 0 516 522 0 jfet04 l=1.2 w=48.0
j1841 455 205 523 0 jfet16 l=1.2 w=8.0
j1842 1 507 455 0 jfet16 l=1.2 w=62.0
j1843 524 524 1 0 jfet16 l=1.2 w=6.0
j1844 525 525 1 0 jfet16 l=1.2 w=6.0
j1845 524 297 0 0 jfet04 l=1.2 w=48.0
j1846 0 297 524 0 jfet04 l=1.2 w=48.0
j1847 525 481 0 0 jfet04 l=1.2 w=48.0
j1848 0 481 525 0 jfet04 l=1.2 w=48.0
j1849 526 481 0 0 jfet04 l=1.2 w=64.0
j1850 0 481 526 0 jfet04 l=1.2 w=64.0
j1851 526 481 0 0 jfet04 l=1.2 w=64.0
j1852 508 524 526 0 jfet04 l=1.2 w=64.0
j1853 526 524 508 0 jfet04 l=1.2 w=64.0
j1854 508 524 526 0 jfet04 l=1.2 w=64.0
j1855 527 508 509 0 jfet04 l=1.2 w=64.0
j1856 509 508 527 0 jfet04 l=1.2 w=64.0
j1857 527 508 509 0 jfet04 l=1.2 w=64.0
j1858 0 511 527 0 jfet04 l=1.2 w=64.0
j1859 527 511 0 0 jfet04 l=1.2 w=64.0
j1860 0 511 527 0 jfet04 l=1.2 w=64.0
j1861 528 524 0 0 jfet04 l=1.2 w=64.0
j1862 0 524 528 0 jfet04 l=1.2 w=64.0
j1863 528 524 0 0 jfet04 l=1.2 w=64.0
j1864 510 525 528 0 jfet04 l=1.2 w=64.0
j1865 528 525 510 0 jfet04 l=1.2 w=64.0
j1866 510 525 528 0 jfet04 l=1.2 w=64.0
j1867 529 510 511 0 jfet04 l=1.2 w=64.0
j1868 511 510 529 0 jfet04 l=1.2 w=64.0
j1869 529 510 511 0 jfet04 l=1.2 w=64.0
j1870 0 509 529 0 jfet04 l=1.2 w=64.0
j1871 529 509 0 0 jfet04 l=1.2 w=64.0
j1872 0 509 529 0 jfet04 l=1.2 w=64.0
j1873 185 177 455 0 jfet16 l=1.2 w=6.0
j1874 1 515 515 0 jfet16 l=1.2 w=6.0
j1875 516 516 1 0 jfet16 l=1.2 w=6.0
j1876 1 454 454 0 jfet16 l=1.2 w=6.0
j1877 451 451 1 0 jfet16 l=1.2 w=6.0
j1878 1 452 452 0 jfet16 l=1.2 w=6.0
j1879 453 453 1 0 jfet16 l=1.2 w=6.0
j1880 1 517 517 0 jfet16 l=1.2 w=6.0
j1881 518 518 1 0 jfet16 l=1.2 w=6.0
j1882 1 519 519 0 jfet16 l=1.2 w=6.0
j1883 520 520 1 0 jfet16 l=1.2 w=6.0
j1884 1 521 521 0 jfet16 l=1.2 w=6.0

j1885 522 522 1 0 jfet16 l=1.2 w=6.0
j1886 530 516 0 0 jfet04 l=1.2 w=64.0
j1887 0 516 530 0 jfet04 l=1.2 w=64.0
j1888 530 516 0 0 jfet04 l=1.2 w=64.0
j1889 531 521 530 0 jfet04 l=1.2 w=64.0
j1890 530 521 531 0 jfet04 l=1.2 w=64.0
j1891 531 521 530 0 jfet04 l=1.2 w=64.0
j1892 532 531 125 0 jfet04 l=1.2 w=64.0
j1893 125 531 532 0 jfet04 l=1.2 w=64.0
j1894 532 531 125 0 jfet04 l=1.2 w=64.0
j1895 0 533 532 0 jfet04 l=1.2 w=64.0
j1896 532 533 0 0 jfet04 l=1.2 w=64.0
j1897 0 533 532 0 jfet04 l=1.2 w=64.0
j1898 534 521 0 0 jfet04 l=1.2 w=64.0
j1899 0 521 534 0 jfet04 l=1.2 w=64.0
j1900 534 521 0 0 jfet04 l=1.2 w=64.0
j1901 535 522 534 0 jfet04 l=1.2 w=64.0
j1902 534 522 535 0 jfet04 l=1.2 w=64.0
j1903 535 522 534 0 jfet04 l=1.2 w=64.0
j1904 536 535 533 0 jfet04 l=1.2 w=64.0
j1905 533 535 536 0 jfet04 l=1.2 w=64.0
j1906 536 535 533 0 jfet04 l=1.2 w=64.0
j1907 0 125 536 0 jfet04 l=1.2 w=64.0
j1908 536 125 0 0 jfet04 l=1.2 w=64.0
j1909 0 125 536 0 jfet04 l=1.2 w=64.0
j1910 455 507 1 0 jfet16 l=1.2 w=62.0
j1911 0 441 537 0 jfet04 l=1.2 w=48.0
j1912 538 441 0 0 jfet04 l=1.2 w=48.0
j1913 1 537 538 0 jfet04 l=1.2 w=48.0
j1914 0 439 539 0 jfet04 l=1.2 w=48.0
j1915 540 439 0 0 jfet04 l=1.2 w=48.0
j1916 1 539 540 0 jfet04 l=1.2 w=48.0
j1917 541 542 1 0 jfet04 l=1.2 w=48.0
j1918 0 243 541 0 jfet04 l=1.2 w=48.0
j1919 542 243 0 0 jfet04 l=1.2 w=48.0
j1920 543 541 0 0 jfet04 l=1.2 w=48.0
j1921 0 540 543 0 jfet04 l=1.2 w=48.0
j1922 543 538 0 0 jfet04 l=1.2 w=48.0
j1923 169 543 1 0 jfet04 l=1.2 w=48.0
j1924 0 538 169 0 jfet04 l=1.2 w=48.0
j1925 169 540 0 0 jfet04 l=1.2 w=48.0
j1926 0 541 169 0 jfet04 l=1.2 w=48.0
j1927 169 543 1 0 jfet04 l=1.2 w=48.0
j1928 0 538 169 0 jfet04 l=1.2 w=48.0
j1929 169 540 0 0 jfet04 l=1.2 w=48.0
j1930 0 541 169 0 jfet04 l=1.2 w=48.0
j1931 169 541 0 0 jfet04 l=1.2 w=48.0
j1932 0 540 169 0 jfet04 l=1.2 w=48.0
j1933 169 538 0 0 jfet04 l=1.2 w=48.0
j1934 1 543 169 0 jfet04 l=1.2 w=48.0
j1935 169 543 1 0 jfet04 l=1.2 w=48.0

j1936 0 538 169 0 jfet04 l=1.2 w=48.0
j1937 169 540 0 0 jfet04 l=1.2 w=48.0
j1938 0 541 169 0 jfet04 l=1.2 w=48.0
j1939 169 541 0 0 jfet04 l=1.2 w=48.0
j1940 0 540 169 0 jfet04 l=1.2 w=48.0
j1941 169 538 0 0 jfet04 l=1.2 w=48.0
j1942 1 543 169 0 jfet04 l=1.2 w=48.0
j1943 544 169 0 0 jfet04 l=1.2 w=48.0
j1944 0 169 544 0 jfet04 l=1.2 w=48.0
j1945 455 214 545 0 jfet16 l=1.2 w=8.0
j1946 546 217 455 0 jfet16 l=1.2 w=8.0
j1947 219 547 219 248 dio16 l=1.2 w=20.0
j1948 548 219 455 0 jfet16 l=1.2 w=8.0
j1949 1 549 549 0 jfet16 l=1.2 w=6.0
j1950 1 550 550 0 jfet16 l=1.2 w=6.0
j1951 551 219 551 248 dio16 l=1.2 w=10.0
j1952 1 552 552 0 jfet16 l=1.2 w=6.0
j1953 1 553 553 0 jfet16 l=1.2 w=6.0
j1954 531 531 1 0 jfet16 l=1.2 w=6.0
j1955 125 125 1 0 jfet16 l=1.2 w=6.0
j1956 535 535 1 0 jfet16 l=1.2 w=6.0
j1957 533 533 1 0 jfet16 l=1.2 w=6.0
j1958 176 177 548 0 jfet16 l=1.2 w=3.2
j1959 248 248 554 0 jfet20 l=3.2 w=3.2
j1960 554 555 554 248 dio16 l=1.2 w=4.0
j1961 1 537 537 0 jfet16 l=1.2 w=3.2
j1962 1 539 539 0 jfet16 l=1.2 w=3.2
j1963 542 542 1 0 jfet16 l=1.2 w=3.2
j1964 555 544 1 0 jfet04 l=1.2 w=20.0
j1965 547 556 547 248 dio16 l=1.2 w=20.0
j1966 248 248 219 0 jfet16 l=1.2 w=12.0
j1967 557 557 1 0 jfet16 l=1.2 w=6.0
j1968 558 551 558 248 dio16 l=1.2 w=10.0
j1969 543 543 1 0 jfet16 l=1.2 w=3.2
j1970 544 544 1 0 jfet16 l=1.2 w=6.0
j1971 559 559 1 0 jfet16 l=1.2 w=3.2
j1972 0 554 559 0 jfet16 l=1.2 w=10.0
j1973 556 559 1 0 jfet16 l=1.2 w=20.0
j1974 560 558 560 248 dio16 l=1.2 w=10.0
j1975 248 560 248 248 dio16 l=1.2 w=10.0
j1976 1 561 561 0 jfet16 l=1.2 w=6.0
j1977 562 562 1 0 jfet16 l=1.2 w=6.0
j1978 563 563 1 0 jfet16 l=1.2 w=6.0
j1979 1 564 564 0 jfet16 l=1.2 w=3.2
j1980 565 565 1 0 jfet16 l=1.2 w=3.2
j1981 1 566 566 0 jfet16 l=1.2 w=3.2
j1982 567 567 1 0 jfet16 l=1.2 w=3.2
j1983 1 568 568 0 jfet16 l=1.2 w=3.2
j1984 1 569 569 0 jfet16 l=1.2 w=6.0
j1985 1 570 570 0 jfet16 l=1.2 w=3.2
j1986 571 571 1 0 jfet16 l=1.2 w=3.2

j1987 1 572 572 0 jfet16 l=1.2 w=3.2
j1988 513 481 0 0 jfet04 l=1.2 w=48.0
j1989 0 481 513 0 jfet04 l=1.2 w=48.0
j1990 573 297 0 0 jfet04 l=1.2 w=48.0
j1991 0 297 573 0 jfet04 l=1.2 w=48.0
j1992 574 501 0 0 jfet04 l=1.2 w=48.0
j1993 0 501 574 0 jfet04 l=1.2 w=48.0
j1994 575 496 0 0 jfet04 l=1.2 w=48.0
j1995 0 496 575 0 jfet04 l=1.2 w=48.0
j1996 576 575 0 0 jfet04 l=1.2 w=48.0
j1997 0 575 576 0 jfet04 l=1.2 w=48.0
j1998 576 574 0 0 jfet04 l=1.2 w=48.0
j1999 0 574 576 0 jfet04 l=1.2 w=48.0
j2000 576 573 0 0 jfet04 l=1.2 w=48.0
j2001 0 573 576 0 jfet04 l=1.2 w=48.0
j2002 514 576 0 0 jfet04 l=1.2 w=48.0
j2003 0 576 514 0 jfet04 l=1.2 w=48.0
j2004 577 481 0 0 jfet04 l=1.2 w=48.0
j2005 0 481 577 0 jfet04 l=1.2 w=48.0
j2006 578 512 0 0 jfet04 l=1.2 w=48.0
j2007 0 512 578 0 jfet04 l=1.2 w=48.0
j2008 579 514 0 0 jfet04 l=1.2 w=48.0
j2009 0 514 579 0 jfet04 l=1.2 w=48.0
j2010 580 579 0 0 jfet04 l=1.2 w=48.0
j2011 0 579 580 0 jfet04 l=1.2 w=48.0
j2012 580 578 0 0 jfet04 l=1.2 w=48.0
j2013 0 578 580 0 jfet04 l=1.2 w=48.0
j2014 580 577 0 0 jfet04 l=1.2 w=48.0
j2015 0 577 580 0 jfet04 l=1.2 w=48.0
j2016 472 580 0 0 jfet04 l=1.2 w=48.0
j2017 0 580 472 0 jfet04 l=1.2 w=48.0
j2018 581 472 0 0 jfet04 l=1.2 w=48.0
j2019 0 472 581 0 jfet04 l=1.2 w=48.0
j2020 582 501 0 0 jfet04 l=1.2 w=48.0
j2021 0 501 582 0 jfet04 l=1.2 w=48.0
j2022 583 582 0 0 jfet04 l=1.2 w=48.0
j2023 0 582 583 0 jfet04 l=1.2 w=48.0
j2024 583 581 0 0 jfet04 l=1.2 w=48.0
j2025 0 581 583 0 jfet04 l=1.2 w=48.0
j2026 512 583 0 0 jfet04 l=1.2 w=48.0
j2027 0 583 512 0 jfet04 l=1.2 w=48.0
j2028 584 584 1 0 jfet16 l=1.2 w=6.0
j2029 585 585 1 0 jfet16 l=1.2 w=6.0
j2030 1 513 513 0 jfet16 l=1.2 w=6.0
j2031 573 573 1 0 jfet16 l=1.2 w=6.0
j2032 574 574 1 0 jfet16 l=1.2 w=6.0
j2033 575 575 1 0 jfet16 l=1.2 w=6.0
j2034 576 576 1 0 jfet16 l=1.2 w=6.0
j2035 514 514 1 0 jfet16 l=1.2 w=6.0
j2036 577 577 1 0 jfet16 l=1.2 w=6.0
j2037 578 578 1 0 jfet16 l=1.2 w=6.0

j2038 579 579 1 0 jfet16 l=1.2 w=6.0
j2039 580 580 1 0 jfet16 l=1.2 w=6.0
j2040 472 472 1 0 jfet16 l=1.2 w=6.0
j2041 581 581 1 0 jfet16 l=1.2 w=6.0
j2042 582 582 1 0 jfet16 l=1.2 w=6.0
j2043 583 583 1 0 jfet16 l=1.2 w=6.0
j2044 512 512 1 0 jfet16 l=1.2 w=6.0
j2045 1 586 586 0 jfet16 l=1.2 w=6.0
j2046 587 587 1 0 jfet16 l=1.2 w=6.0
j2047 1 588 588 0 jfet16 l=1.2 w=6.0
j2048 1 589 589 0 jfet16 l=1.2 w=6.0
j2049 590 590 1 0 jfet16 l=1.2 w=6.0
j2050 1 591 591 0 jfet16 l=1.2 w=6.0
j2051 584 524 0 0 jfet04 l=1.2 w=48.0
j2052 0 524 584 0 jfet04 l=1.2 w=48.0
j2053 585 509 0 0 jfet04 l=1.2 w=48.0
j2054 0 509 585 0 jfet04 l=1.2 w=48.0
j2055 592 509 0 0 jfet04 l=1.2 w=64.0
j2056 0 509 592 0 jfet04 l=1.2 w=64.0
j2057 592 509 0 0 jfet04 l=1.2 w=64.0
j2058 569 584 592 0 jfet04 l=1.2 w=64.0
j2059 592 584 569 0 jfet04 l=1.2 w=64.0
j2060 569 584 592 0 jfet04 l=1.2 w=64.0
j2061 0 569 570 0 jfet04 l=1.2 w=48.0
j2062 593 569 0 0 jfet04 l=1.2 w=48.0
j2063 1 570 593 0 jfet04 l=1.2 w=48.0
j2064 594 571 1 0 jfet04 l=1.2 w=48.0
j2065 0 595 594 0 jfet04 l=1.2 w=48.0
j2066 571 595 0 0 jfet04 l=1.2 w=48.0
j2067 1 596 596 0 jfet16 l=1.2 w=3.2
j2068 0 593 572 0 jfet04 l=1.2 w=48.0
j2069 572 594 0 0 jfet04 l=1.2 w=48.0
j2070 597 572 1 0 jfet04 l=1.2 w=48.0
j2071 0 594 597 0 jfet04 l=1.2 w=48.0
j2072 597 593 0 0 jfet04 l=1.2 w=48.0
j2073 0 597 596 0 jfet04 l=1.2 w=48.0
j2074 598 597 0 0 jfet04 l=1.2 w=48.0
j2075 1 596 598 0 jfet04 l=1.2 w=48.0
j2076 561 599 0 0 jfet04 l=1.2 w=48.0
j2077 0 599 561 0 jfet04 l=1.2 w=48.0
j2078 562 600 0 0 jfet04 l=1.2 w=48.0
j2079 0 600 562 0 jfet04 l=1.2 w=48.0
j2080 563 439 0 0 jfet04 l=1.2 w=48.0
j2081 0 439 563 0 jfet04 l=1.2 w=48.0
j2082 0 441 564 0 jfet04 l=1.2 w=48.0
j2083 601 441 0 0 jfet04 l=1.2 w=48.0
j2084 1 564 601 0 jfet04 l=1.2 w=48.0
j2085 602 565 1 0 jfet04 l=1.2 w=48.0
j2086 0 561 602 0 jfet04 l=1.2 w=48.0
j2087 565 561 0 0 jfet04 l=1.2 w=48.0
j2088 0 562 566 0 jfet04 l=1.2 w=48.0

j2089 603 562 0 0 jfet04 l=1.2 w=48.0
j2090 1 566 603 0 jfet04 l=1.2 w=48.0
j2091 557 604 0 0 jfet04 l=1.2 w=48.0
j2092 0 604 557 0 jfet04 l=1.2 w=48.0
j2093 605 604 0 0 jfet04 l=1.2 w=64.0
j2094 0 604 605 0 jfet04 l=1.2 w=64.0
j2095 605 604 0 0 jfet04 l=1.2 w=64.0
j2096 549 227 605 0 jfet04 l=1.2 w=64.0
j2097 605 227 549 0 jfet04 l=1.2 w=64.0
j2098 549 227 605 0 jfet04 l=1.2 w=64.0
j2099 606 549 550 0 jfet04 l=1.2 w=64.0
j2100 550 549 606 0 jfet04 l=1.2 w=64.0
j2101 606 549 550 0 jfet04 l=1.2 w=64.0
j2102 0 553 606 0 jfet04 l=1.2 w=64.0
j2103 606 553 0 0 jfet04 l=1.2 w=64.0
j2104 0 553 606 0 jfet04 l=1.2 w=64.0
j2105 607 227 0 0 jfet04 l=1.2 w=64.0
j2106 0 227 607 0 jfet04 l=1.2 w=64.0
j2107 607 227 0 0 jfet04 l=1.2 w=64.0
j2108 552 557 607 0 jfet04 l=1.2 w=64.0
j2109 607 557 552 0 jfet04 l=1.2 w=64.0
j2110 552 557 607 0 jfet04 l=1.2 w=64.0
j2111 608 552 553 0 jfet04 l=1.2 w=64.0
j2112 553 552 608 0 jfet04 l=1.2 w=64.0
j2113 608 552 553 0 jfet04 l=1.2 w=64.0
j2114 0 550 608 0 jfet04 l=1.2 w=64.0
j2115 608 550 0 0 jfet04 l=1.2 w=64.0
j2116 0 550 608 0 jfet04 l=1.2 w=64.0
j2117 1 609 609 0 jfet16 l=1.2 w=6.0
j2118 610 610 1 0 jfet16 l=1.2 w=6.0
j2119 1 611 611 0 jfet16 l=1.2 w=6.0
j2120 612 612 1 0 jfet16 l=1.2 w=6.0
j2121 1 483 483 0 jfet16 l=1.2 w=6.0
j2122 1 613 613 0 jfet16 l=1.2 w=6.0
j2123 614 614 1 0 jfet16 l=1.2 w=6.0
j2124 1 615 615 0 jfet16 l=1.2 w=6.0
j2125 616 616 1 0 jfet16 l=1.2 w=6.0
j2126 1 617 617 0 jfet16 l=1.2 w=6.0
j2127 618 618 1 0 jfet16 l=1.2 w=6.0
j2128 619 619 1 0 jfet16 l=1.2 w=3.2
j2129 609 620 0 0 jfet04 l=1.2 w=48.0
j2130 0 620 609 0 jfet04 l=1.2 w=48.0
j2131 610 553 0 0 jfet04 l=1.2 w=48.0
j2132 0 553 610 0 jfet04 l=1.2 w=48.0
j2133 611 243 0 0 jfet04 l=1.2 w=48.0
j2134 0 243 611 0 jfet04 l=1.2 w=48.0
j2135 612 244 0 0 jfet04 l=1.2 w=48.0
j2136 0 244 612 0 jfet04 l=1.2 w=48.0
j2137 483 612 0 0 jfet04 l=1.2 w=48.0
j2138 0 612 483 0 jfet04 l=1.2 w=48.0
j2139 483 611 0 0 jfet04 l=1.2 w=48.0

j2140 0 611 483 0 jfet04 l=1.2 w=48.0
j2141 483 610 0 0 jfet04 l=1.2 w=48.0
j2142 0 610 483 0 jfet04 l=1.2 w=48.0
j2143 483 609 0 0 jfet04 l=1.2 w=48.0
j2144 0 609 483 0 jfet04 l=1.2 w=48.0
j2145 613 620 0 0 jfet04 l=1.2 w=48.0
j2146 0 620 613 0 jfet04 l=1.2 w=48.0
j2147 614 550 0 0 jfet04 l=1.2 w=48.0
j2148 0 550 614 0 jfet04 l=1.2 w=48.0
j2149 615 244 0 0 jfet04 l=1.2 w=48.0
j2150 0 244 615 0 jfet04 l=1.2 w=48.0
j2151 616 243 0 0 jfet04 l=1.2 w=48.0
j2152 0 243 616 0 jfet04 l=1.2 w=48.0
j2153 617 616 0 0 jfet04 l=1.2 w=48.0
j2154 0 616 617 0 jfet04 l=1.2 w=48.0
j2155 617 615 0 0 jfet04 l=1.2 w=48.0
j2156 0 615 617 0 jfet04 l=1.2 w=48.0
j2157 617 614 0 0 jfet04 l=1.2 w=48.0
j2158 0 614 617 0 jfet04 l=1.2 w=48.0
j2159 617 613 0 0 jfet04 l=1.2 w=48.0
j2160 0 613 617 0 jfet04 l=1.2 w=48.0
j2161 618 617 0 0 jfet04 l=1.2 w=48.0
j2162 0 617 618 0 jfet04 l=1.2 w=48.0
j2163 621 618 1 0 jfet04 l=1.2 w=20.0
j2164 0 622 619 0 jfet16 l=1.2 w=10.0
j2165 623 619 1 0 jfet16 l=1.2 w=20.0
j2166 248 624 248 248 dio16 l=1.2 w=10.0
j2167 622 621 622 248 dio16 l=1.2 w=4.0
j2168 622 248 248 0 jfet20 l=3.2 w=3.2
j2169 625 623 625 248 dio16 l=1.2 w=20.0
j2170 624 626 624 248 dio16 l=1.2 w=10.0
j2171 248 248 507 0 jfet16 l=1.2 w=12.0
j2172 626 627 626 248 dio16 l=1.2 w=10.0
j2173 627 507 627 248 dio16 l=1.2 w=10.0
j2174 507 625 507 248 dio16 l=1.2 w=20.0
j2175 628 567 1 0 jfet04 l=1.2 w=48.0
j2176 0 563 628 0 jfet04 l=1.2 w=48.0
j2177 567 563 0 0 jfet04 l=1.2 w=48.0
j2178 0 601 568 0 jfet04 l=1.2 w=48.0
j2179 568 602 0 0 jfet04 l=1.2 w=48.0
j2180 0 603 568 0 jfet04 l=1.2 w=48.0
j2181 568 628 0 0 jfet04 l=1.2 w=48.0
j2182 629 568 1 0 jfet04 l=1.2 w=48.0
j2183 0 628 629 0 jfet04 l=1.2 w=48.0
j2184 629 603 0 0 jfet04 l=1.2 w=48.0
j2185 0 602 629 0 jfet04 l=1.2 w=48.0
j2186 629 601 0 0 jfet04 l=1.2 w=48.0
j2187 1 630 630 0 jfet16 l=1.2 w=6.0
j2188 631 631 1 0 jfet16 l=1.2 w=6.0
j2189 1 632 632 0 jfet16 l=1.2 w=6.0
j2190 633 633 1 0 jfet16 l=1.2 w=6.0

j2191 634 634 1 0 jfet16 l=1.2 w=3.2
j2192 1 635 635 0 jfet16 l=1.2 w=6.0
j2193 636 636 1 0 jfet16 l=1.2 w=6.0
j2194 637 637 1 0 jfet16 l=1.2 w=6.0
j2195 638 638 1 0 jfet16 l=1.2 w=6.0
j2196 639 639 1 0 jfet16 l=1.2 w=6.0
j2197 1 640 640 0 jfet16 l=1.2 w=6.0
j2198 641 641 1 0 jfet16 l=1.2 w=6.0
j2199 642 642 1 0 jfet16 l=1.2 w=6.0
j2200 643 643 1 0 jfet16 l=1.2 w=6.0
j2201 644 644 1 0 jfet16 l=1.2 w=6.0
j2202 1 645 645 0 jfet16 l=1.2 w=6.0
j2203 646 646 1 0 jfet16 l=1.2 w=6.0
j2204 647 647 1 0 jfet16 l=1.2 w=6.0
j2205 648 648 1 0 jfet16 l=1.2 w=6.0
j2206 1 649 649 0 jfet16 l=1.2 w=6.0
j2207 650 650 1 0 jfet16 l=1.2 w=6.0
j2208 586 472 0 0 jfet04 l=1.2 w=48.0
j2209 0 472 586 0 jfet04 l=1.2 w=48.0
j2210 587 651 0 0 jfet04 l=1.2 w=48.0
j2211 0 651 587 0 jfet04 l=1.2 w=48.0
j2212 588 586 0 0 jfet04 l=1.2 w=48.0
j2213 0 586 588 0 jfet04 l=1.2 w=48.0
j2214 588 587 0 0 jfet04 l=1.2 w=48.0
j2215 0 587 588 0 jfet04 l=1.2 w=48.0
j2216 589 513 0 0 jfet04 l=1.2 w=48.0
j2217 0 513 589 0 jfet04 l=1.2 w=48.0
j2218 590 651 0 0 jfet04 l=1.2 w=48.0
j2219 0 651 590 0 jfet04 l=1.2 w=48.0
j2220 591 589 0 0 jfet04 l=1.2 w=48.0
j2221 0 589 591 0 jfet04 l=1.2 w=48.0
j2222 591 590 0 0 jfet04 l=1.2 w=48.0
j2223 0 590 591 0 jfet04 l=1.2 w=48.0
j2224 635 652 0 0 jfet04 l=1.2 w=48.0
j2225 0 652 635 0 jfet04 l=1.2 w=48.0
j2226 635 588 0 0 jfet04 l=1.2 w=48.0
j2227 0 588 635 0 jfet04 l=1.2 w=48.0
j2228 635 653 0 0 jfet04 l=1.2 w=48.0
j2229 0 653 635 0 jfet04 l=1.2 w=48.0
j2230 636 635 0 0 jfet04 l=1.2 w=48.0
j2231 0 635 636 0 jfet04 l=1.2 w=48.0
j2232 637 636 0 0 jfet04 l=1.2 w=48.0
j2233 0 636 637 0 jfet04 l=1.2 w=48.0
j2234 638 481 0 0 jfet04 l=1.2 w=48.0
j2235 0 481 638 0 jfet04 l=1.2 w=48.0
j2236 639 654 0 0 jfet04 l=1.2 w=48.0
j2237 0 654 639 0 jfet04 l=1.2 w=48.0
j2238 640 639 0 0 jfet04 l=1.2 w=48.0
j2239 0 639 640 0 jfet04 l=1.2 w=48.0
j2240 640 638 0 0 jfet04 l=1.2 w=48.0
j2241 0 638 640 0 jfet04 l=1.2 w=48.0

j2242 640 637 0 0 jfet04 l=1.2 w=48.0
j2243 0 637 640 0 jfet04 l=1.2 w=48.0
j2244 641 640 0 0 jfet04 l=1.2 w=48.0
j2245 0 640 641 0 jfet04 l=1.2 w=48.0
j2246 642 481 0 0 jfet04 l=1.2 w=48.0
j2247 0 481 642 0 jfet04 l=1.2 w=48.0
j2248 643 650 0 0 jfet04 l=1.2 w=48.0
j2249 0 650 643 0 jfet04 l=1.2 w=48.0
j2250 644 297 0 0 jfet04 l=1.2 w=48.0
j2251 0 297 644 0 jfet04 l=1.2 w=48.0
j2252 645 644 0 0 jfet04 l=1.2 w=48.0
j2253 0 644 645 0 jfet04 l=1.2 w=48.0
j2254 645 643 0 0 jfet04 l=1.2 w=48.0
j2255 0 643 645 0 jfet04 l=1.2 w=48.0
j2256 645 642 0 0 jfet04 l=1.2 w=48.0
j2257 0 642 645 0 jfet04 l=1.2 w=48.0
j2258 646 645 0 0 jfet04 l=1.2 w=48.0
j2259 0 645 646 0 jfet04 l=1.2 w=48.0
j2260 647 646 0 0 jfet04 l=1.2 w=48.0
j2261 0 646 647 0 jfet04 l=1.2 w=48.0
j2262 648 641 0 0 jfet04 l=1.2 w=48.0
j2263 0 641 648 0 jfet04 l=1.2 w=48.0
j2264 649 648 0 0 jfet04 l=1.2 w=48.0
j2265 0 648 649 0 jfet04 l=1.2 w=48.0
j2266 649 647 0 0 jfet04 l=1.2 w=48.0
j2267 0 647 649 0 jfet04 l=1.2 w=48.0
j2268 650 649 0 0 jfet04 l=1.2 w=48.0
j2269 0 649 650 0 jfet04 l=1.2 w=48.0
j2270 595 655 1 0 jfet04 l=1.2 w=48.0
j2271 0 656 595 0 jfet04 l=1.2 w=48.0
j2272 655 656 0 0 jfet04 l=1.2 w=48.0
j2273 0 657 656 0 jfet04 l=1.2 w=48.0
j2274 656 658 0 0 jfet04 l=1.2 w=48.0
j2275 1 659 656 0 jfet04 l=1.2 w=48.0
j2276 0 658 659 0 jfet04 l=1.2 w=48.0
j2277 659 657 0 0 jfet04 l=1.2 w=48.0
j2278 655 655 1 0 jfet16 l=1.2 w=3.2
j2279 0 598 660 0 jfet04 l=1.2 w=48.0
j2280 658 598 0 0 jfet04 l=1.2 w=48.0
j2281 1 660 658 0 jfet04 l=1.2 w=48.0
j2282 657 661 1 0 jfet04 l=1.2 w=48.0
j2283 0 662 657 0 jfet04 l=1.2 w=48.0
j2284 661 662 0 0 jfet04 l=1.2 w=48.0
j2285 663 584 662 0 jfet04 l=1.2 w=64.0
j2286 662 584 663 0 jfet04 l=1.2 w=64.0
j2287 663 584 662 0 jfet04 l=1.2 w=64.0
j2288 0 585 663 0 jfet04 l=1.2 w=64.0
j2289 663 585 0 0 jfet04 l=1.2 w=64.0
j2290 0 585 663 0 jfet04 l=1.2 w=64.0
j2291 0 441 664 0 jfet04 l=1.2 w=48.0
j2292 665 441 0 0 jfet04 l=1.2 w=48.0

j2293 1 664 665 0 jfet04 l=1.2 w=48.0
j2294 666 667 1 0 jfet04 l=1.2 w=48.0
j2295 0 561 666 0 jfet04 l=1.2 w=48.0
j2296 667 561 0 0 jfet04 l=1.2 w=48.0
j2297 0 562 668 0 jfet04 l=1.2 w=48.0
j2298 669 562 0 0 jfet04 l=1.2 w=48.0
j2299 1 668 669 0 jfet04 l=1.2 w=48.0
j2300 670 671 1 0 jfet04 l=1.2 w=48.0
j2301 0 439 670 0 jfet04 l=1.2 w=48.0
j2302 671 439 0 0 jfet04 l=1.2 w=48.0
j2303 0 665 672 0 jfet04 l=1.2 w=48.0
j2304 672 666 0 0 jfet04 l=1.2 w=48.0
j2305 0 669 672 0 jfet04 l=1.2 w=48.0
j2306 672 670 0 0 jfet04 l=1.2 w=48.0
j2307 673 672 1 0 jfet04 l=1.2 w=48.0
j2308 0 670 673 0 jfet04 l=1.2 w=48.0
j2309 673 669 0 0 jfet04 l=1.2 w=48.0
j2310 0 666 673 0 jfet04 l=1.2 w=48.0
j2311 673 665 0 0 jfet04 l=1.2 w=48.0
j2312 630 629 0 0 jfet04 l=1.2 w=48.0
j2313 0 629 630 0 jfet04 l=1.2 w=48.0
j2314 631 243 0 0 jfet04 l=1.2 w=48.0
j2315 0 243 631 0 jfet04 l=1.2 w=48.0
j2316 632 630 0 0 jfet04 l=1.2 w=48.0
j2317 0 630 632 0 jfet04 l=1.2 w=48.0
j2318 632 631 0 0 jfet04 l=1.2 w=48.0
j2319 0 631 632 0 jfet04 l=1.2 w=48.0
j2320 633 632 0 0 jfet04 l=1.2 w=48.0
j2321 0 632 633 0 jfet04 l=1.2 w=48.0
j2322 674 633 1 0 jfet04 l=1.2 w=20.0
j2323 0 675 634 0 jfet16 l=1.2 w=10.0
j2324 676 634 1 0 jfet16 l=1.2 w=20.0
j2325 248 677 248 248 dio16 l=1.2 w=10.0
j2326 675 674 675 248 dio16 l=1.2 w=4.0
j2327 675 248 248 0 jfet20 l=3.2 w=3.2
j2328 678 676 678 248 dio16 l=1.2 w=20.0
j2329 677 679 677 248 dio16 l=1.2 w=10.0
j2330 248 248 194 0 jfet16 l=1.2 w=12.0
j2331 679 680 679 248 dio16 l=1.2 w=10.0
j2332 680 194 680 248 dio16 l=1.2 w=10.0
j2333 194 678 194 248 dio16 l=1.2 w=20.0
j2334 1 664 664 0 jfet16 l=1.2 w=3.2
j2335 667 667 1 0 jfet16 l=1.2 w=3.2
j2336 1 668 668 0 jfet16 l=1.2 w=3.2
j2337 671 671 1 0 jfet16 l=1.2 w=3.2
j2338 672 672 1 0 jfet16 l=1.2 w=3.2
j2339 659 659 1 0 jfet16 l=1.2 w=3.2
j2340 1 660 660 0 jfet16 l=1.2 w=3.2
j2341 661 661 1 0 jfet16 l=1.2 w=3.2
j2342 1 681 681 0 jfet16 l=1.2 w=3.2
j2343 682 682 1 0 jfet16 l=1.2 w=3.2

j2344 1 683 683 0 jfet16 l=1.2 w=3.2
j2345 684 684 1 0 jfet16 l=1.2 w=3.2
j2346 1 685 685 0 jfet16 l=1.2 w=3.2
j2347 686 673 0 0 jfet04 l=1.2 w=48.0
j2348 0 673 686 0 jfet04 l=1.2 w=48.0
j2349 687 243 0 0 jfet04 l=1.2 w=48.0
j2350 0 243 687 0 jfet04 l=1.2 w=48.0
j2351 688 686 0 0 jfet04 l=1.2 w=48.0
j2352 0 686 688 0 jfet04 l=1.2 w=48.0
j2353 688 687 0 0 jfet04 l=1.2 w=48.0
j2354 0 687 688 0 jfet04 l=1.2 w=48.0
j2355 689 688 0 0 jfet04 l=1.2 w=48.0
j2356 0 688 689 0 jfet04 l=1.2 w=48.0
j2357 188 690 188 248 dio16 l=1.2 w=20.0
j2358 691 188 691 248 dio16 l=1.2 w=10.0
j2359 620 253 0 0 jfet04 l=1.2 w=48.0
j2360 0 253 620 0 jfet04 l=1.2 w=48.0
j2361 692 253 0 0 jfet04 l=1.2 w=48.0
j2362 0 253 692 0 jfet04 l=1.2 w=48.0
j2363 693 553 0 0 jfet04 l=1.2 w=48.0
j2364 0 553 693 0 jfet04 l=1.2 w=48.0
j2365 694 243 0 0 jfet04 l=1.2 w=48.0
j2366 0 243 694 0 jfet04 l=1.2 w=48.0
j2367 695 244 0 0 jfet04 l=1.2 w=48.0
j2368 0 244 695 0 jfet04 l=1.2 w=48.0
j2369 482 695 0 0 jfet04 l=1.2 w=48.0
j2370 0 695 482 0 jfet04 l=1.2 w=48.0
j2371 482 694 0 0 jfet04 l=1.2 w=48.0
j2372 0 694 482 0 jfet04 l=1.2 w=48.0
j2373 482 693 0 0 jfet04 l=1.2 w=48.0
j2374 0 693 482 0 jfet04 l=1.2 w=48.0
j2375 482 692 0 0 jfet04 l=1.2 w=48.0
j2376 0 692 482 0 jfet04 l=1.2 w=48.0
j2377 696 253 0 0 jfet04 l=1.2 w=48.0
j2378 0 253 696 0 jfet04 l=1.2 w=48.0
j2379 697 550 0 0 jfet04 l=1.2 w=48.0
j2380 0 550 697 0 jfet04 l=1.2 w=48.0
j2381 698 244 0 0 jfet04 l=1.2 w=48.0
j2382 0 244 698 0 jfet04 l=1.2 w=48.0
j2383 699 243 0 0 jfet04 l=1.2 w=48.0
j2384 0 243 699 0 jfet04 l=1.2 w=48.0
j2385 700 699 0 0 jfet04 l=1.2 w=48.0
j2386 0 699 700 0 jfet04 l=1.2 w=48.0
j2387 700 698 0 0 jfet04 l=1.2 w=48.0
j2388 0 698 700 0 jfet04 l=1.2 w=48.0
j2389 700 697 0 0 jfet04 l=1.2 w=48.0
j2390 0 697 700 0 jfet04 l=1.2 w=48.0
j2391 700 696 0 0 jfet04 l=1.2 w=48.0
j2392 0 696 700 0 jfet04 l=1.2 w=48.0
j2393 701 700 0 0 jfet04 l=1.2 w=48.0
j2394 0 700 701 0 jfet04 l=1.2 w=48.0

j2395 462 702 462 248 dio16 l=1.2 w=20.0
j2396 703 462 703 248 dio16 l=1.2 w=10.0
j2397 248 248 704 0 jfet20 l=3.2 w=3.2
j2398 704 705 704 248 dio16 l=1.2 w=4.0
j2399 248 248 706 0 jfet20 l=3.2 w=3.2
j2400 706 707 706 248 dio16 l=1.2 w=4.0
j2401 662 662 1 0 jfet16 l=1.2 w=6.0
j2402 1 708 708 0 jfet16 l=1.2 w=6.0
j2403 1 709 709 0 jfet16 l=1.2 w=6.0
j2404 710 710 1 0 jfet16 l=1.2 w=6.0
j2405 1 711 711 0 jfet16 l=1.2 w=6.0
j2406 1 712 712 0 jfet16 l=1.2 w=6.0
j2407 713 713 1 0 jfet16 l=1.2 w=6.0
j2408 1 714 714 0 jfet16 l=1.2 w=6.0
j2409 1 715 715 0 jfet16 l=1.2 w=6.0
j2410 716 716 1 0 jfet16 l=1.2 w=6.0
j2411 717 717 1 0 jfet16 l=1.2 w=6.0
j2412 718 718 1 0 jfet16 l=1.2 w=6.0
j2413 1 719 719 0 jfet16 l=1.2 w=6.0
j2414 439 439 1 0 jfet16 l=1.2 w=6.0
j2415 720 512 0 0 jfet04 l=1.2 w=48.0
j2416 0 512 720 0 jfet04 l=1.2 w=48.0
j2417 721 481 0 0 jfet04 l=1.2 w=48.0
j2418 0 481 721 0 jfet04 l=1.2 w=48.0
j2419 722 473 0 0 jfet04 l=1.2 w=48.0
j2420 0 473 722 0 jfet04 l=1.2 w=48.0
j2421 653 722 0 0 jfet04 l=1.2 w=48.0
j2422 0 722 653 0 jfet04 l=1.2 w=48.0
j2423 653 721 0 0 jfet04 l=1.2 w=48.0
j2424 0 721 653 0 jfet04 l=1.2 w=48.0
j2425 653 720 0 0 jfet04 l=1.2 w=48.0
j2426 0 720 653 0 jfet04 l=1.2 w=48.0
j2427 723 297 0 0 jfet04 l=1.2 w=48.0
j2428 0 297 723 0 jfet04 l=1.2 w=48.0
j2429 724 646 0 0 jfet04 l=1.2 w=48.0
j2430 0 646 724 0 jfet04 l=1.2 w=48.0
j2431 725 641 0 0 jfet04 l=1.2 w=48.0
j2432 0 641 725 0 jfet04 l=1.2 w=48.0
j2433 726 725 0 0 jfet04 l=1.2 w=48.0
j2434 0 725 726 0 jfet04 l=1.2 w=48.0
j2435 726 724 0 0 jfet04 l=1.2 w=48.0
j2436 0 724 726 0 jfet04 l=1.2 w=48.0
j2437 726 723 0 0 jfet04 l=1.2 w=48.0
j2438 0 723 726 0 jfet04 l=1.2 w=48.0
j2439 654 726 0 0 jfet04 l=1.2 w=48.0
j2440 0 726 654 0 jfet04 l=1.2 w=48.0
j2441 727 481 0 0 jfet04 l=1.2 w=48.0
j2442 0 481 727 0 jfet04 l=1.2 w=48.0
j2443 728 651 0 0 jfet04 l=1.2 w=48.0
j2444 0 651 728 0 jfet04 l=1.2 w=48.0
j2445 729 654 0 0 jfet04 l=1.2 w=48.0

j2446 0 654 729 0 jfet04 l=1.2 w=48.0
j2447 730 729 0 0 jfet04 l=1.2 w=48.0
j2448 0 729 730 0 jfet04 l=1.2 w=48.0
j2449 730 728 0 0 jfet04 l=1.2 w=48.0
j2450 0 728 730 0 jfet04 l=1.2 w=48.0
j2451 730 727 0 0 jfet04 l=1.2 w=48.0
j2452 0 727 730 0 jfet04 l=1.2 w=48.0
j2453 473 730 0 0 jfet04 l=1.2 w=48.0
j2454 0 730 473 0 jfet04 l=1.2 w=48.0
j2455 731 473 0 0 jfet04 l=1.2 w=48.0
j2456 0 473 731 0 jfet04 l=1.2 w=48.0
j2457 732 646 0 0 jfet04 l=1.2 w=48.0
j2458 0 646 732 0 jfet04 l=1.2 w=48.0
j2459 733 732 0 0 jfet04 l=1.2 w=48.0
j2460 0 732 733 0 jfet04 l=1.2 w=48.0
j2461 733 731 0 0 jfet04 l=1.2 w=48.0
j2462 0 731 733 0 jfet04 l=1.2 w=48.0
j2463 651 733 0 0 jfet04 l=1.2 w=48.0
j2464 0 733 651 0 jfet04 l=1.2 w=48.0
j2465 708 734 0 0 jfet04 l=1.2 w=48.0
j2466 0 734 708 0 jfet04 l=1.2 w=48.0
j2467 709 253 0 0 jfet04 l=1.2 w=48.0
j2468 0 253 709 0 jfet04 l=1.2 w=48.0
j2469 710 595 0 0 jfet04 l=1.2 w=48.0
j2470 0 595 710 0 jfet04 l=1.2 w=48.0
j2471 711 709 0 0 jfet04 l=1.2 w=48.0
j2472 0 709 711 0 jfet04 l=1.2 w=48.0
j2473 711 710 0 0 jfet04 l=1.2 w=48.0
j2474 0 710 711 0 jfet04 l=1.2 w=48.0
j2475 712 253 0 0 jfet04 l=1.2 w=48.0
j2476 0 253 712 0 jfet04 l=1.2 w=48.0
j2477 713 512 0 0 jfet04 l=1.2 w=48.0
j2478 0 512 713 0 jfet04 l=1.2 w=48.0
j2479 714 712 0 0 jfet04 l=1.2 w=48.0
j2480 0 712 714 0 jfet04 l=1.2 w=48.0
j2481 714 713 0 0 jfet04 l=1.2 w=48.0
j2482 0 713 714 0 jfet04 l=1.2 w=48.0
j2483 715 598 0 0 jfet04 l=1.2 w=48.0
j2484 0 598 715 0 jfet04 l=1.2 w=48.0
j2485 716 708 0 0 jfet04 l=1.2 w=48.0
j2486 0 708 716 0 jfet04 l=1.2 w=48.0
j2487 717 512 0 0 jfet04 l=1.2 w=48.0
j2488 0 512 717 0 jfet04 l=1.2 w=48.0
j2489 718 717 0 0 jfet04 l=1.2 w=48.0
j2490 0 717 718 0 jfet04 l=1.2 w=48.0
j2491 718 716 0 0 jfet04 l=1.2 w=48.0
j2492 0 716 718 0 jfet04 l=1.2 w=48.0
j2493 718 715 0 0 jfet04 l=1.2 w=48.0
j2494 0 715 718 0 jfet04 l=1.2 w=48.0
j2495 719 718 0 0 jfet04 l=1.2 w=48.0
j2496 0 718 719 0 jfet04 l=1.2 w=48.0

j2497 719 714 0 0 jfet04 l=1.2 w=48.0
j2498 0 714 719 0 jfet04 l=1.2 w=48.0
j2499 719 711 0 0 jfet04 l=1.2 w=48.0
j2500 0 711 719 0 jfet04 l=1.2 w=48.0
j2501 439 719 0 0 jfet04 l=1.2 w=48.0
j2502 0 719 439 0 jfet04 l=1.2 w=48.0
j2503 0 441 681 0 jfet04 l=1.2 w=48.0
j2504 735 441 0 0 jfet04 l=1.2 w=48.0
j2505 1 681 735 0 jfet04 l=1.2 w=48.0
j2506 736 682 1 0 jfet04 l=1.2 w=48.0
j2507 0 561 736 0 jfet04 l=1.2 w=48.0
j2508 682 561 0 0 jfet04 l=1.2 w=48.0
j2509 0 600 683 0 jfet04 l=1.2 w=48.0
j2510 737 600 0 0 jfet04 l=1.2 w=48.0
j2511 1 683 737 0 jfet04 l=1.2 w=48.0
j2512 738 684 1 0 jfet04 l=1.2 w=48.0
j2513 0 563 738 0 jfet04 l=1.2 w=48.0
j2514 684 563 0 0 jfet04 l=1.2 w=48.0
j2515 0 735 685 0 jfet04 l=1.2 w=48.0
j2516 685 736 0 0 jfet04 l=1.2 w=48.0
j2517 0 737 685 0 jfet04 l=1.2 w=48.0
j2518 685 738 0 0 jfet04 l=1.2 w=48.0
j2519 739 685 1 0 jfet04 l=1.2 w=48.0
j2520 0 738 739 0 jfet04 l=1.2 w=48.0
j2521 739 737 0 0 jfet04 l=1.2 w=48.0
j2522 0 736 739 0 jfet04 l=1.2 w=48.0
j2523 739 735 0 0 jfet04 l=1.2 w=48.0
j2524 707 689 1 0 jfet04 l=1.2 w=20.0
j2525 690 740 690 248 dio16 l=1.2 w=20.0
j2526 248 248 188 0 jfet16 l=1.2 w=12.0
j2527 620 620 1 0 jfet16 l=1.2 w=6.0
j2528 1 692 692 0 jfet16 l=1.2 w=6.0
j2529 693 693 1 0 jfet16 l=1.2 w=6.0
j2530 1 694 694 0 jfet16 l=1.2 w=6.0
j2531 695 695 1 0 jfet16 l=1.2 w=6.0
j2532 705 701 1 0 jfet04 l=1.2 w=20.0
j2533 702 741 702 248 dio16 l=1.2 w=20.0
j2534 248 248 462 0 jfet16 l=1.2 w=12.0
j2535 742 703 742 248 dio16 l=1.2 w=10.0
j2536 482 482 1 0 jfet16 l=1.2 w=6.0
j2537 1 696 696 0 jfet16 l=1.2 w=6.0
j2538 697 697 1 0 jfet16 l=1.2 w=6.0
j2539 1 698 698 0 jfet16 l=1.2 w=6.0
j2540 699 699 1 0 jfet16 l=1.2 w=6.0
j2541 700 700 1 0 jfet16 l=1.2 w=6.0
j2542 701 701 1 0 jfet16 l=1.2 w=6.0
j2543 743 743 1 0 jfet16 l=1.2 w=3.2
j2544 0 704 743 0 jfet16 l=1.2 w=10.0
j2545 741 743 1 0 jfet16 l=1.2 w=20.0
j2546 744 742 744 248 dio16 l=1.2 w=10.0
j2547 248 744 248 248 dio16 l=1.2 w=10.0

j2548 745 691 745 248 dio16 l=1.2 w=10.0
j2549 1 746 746 0 jfet16 l=1.2 w=6.0
j2550 747 747 1 0 jfet16 l=1.2 w=6.0
j2551 1 748 748 0 jfet16 l=1.2 w=6.0
j2552 749 749 1 0 jfet16 l=1.2 w=6.0
j2553 1 686 686 0 jfet16 l=1.2 w=6.0
j2554 687 687 1 0 jfet16 l=1.2 w=6.0
j2555 1 688 688 0 jfet16 l=1.2 w=6.0
j2556 689 689 1 0 jfet16 l=1.2 w=6.0
j2557 750 750 1 0 jfet16 l=1.2 w=3.2
j2558 0 706 750 0 jfet16 l=1.2 w=10.0
j2559 740 750 1 0 jfet16 l=1.2 w=20.0
j2560 751 745 751 248 dio16 l=1.2 w=10.0
j2561 1 752 752 0 jfet16 l=1.2 w=6.0
j2562 1 753 753 0 jfet16 l=1.2 w=6.0
j2563 754 754 1 0 jfet16 l=1.2 w=6.0
j2564 1 755 755 0 jfet16 l=1.2 w=6.0
j2565 756 756 1 0 jfet16 l=1.2 w=6.0
j2566 1 757 757 0 jfet16 l=1.2 w=6.0
j2567 1 758 758 0 jfet16 l=1.2 w=6.0
j2568 759 759 1 0 jfet16 l=1.2 w=6.0
j2569 1 760 760 0 jfet16 l=1.2 w=6.0
j2570 761 761 1 0 jfet16 l=1.2 w=6.0
j2571 1 762 762 0 jfet16 l=1.2 w=6.0
j2572 1 763 763 0 jfet16 l=1.2 w=6.0
j2573 764 764 1 0 jfet16 l=1.2 w=6.0
j2574 1 765 765 0 jfet16 l=1.2 w=6.0
j2575 766 766 1 0 jfet16 l=1.2 w=6.0
j2576 1 767 767 0 jfet16 l=1.2 w=6.0
j2577 248 751 248 248 dio16 l=1.2 w=10.0
j2578 1 768 768 0 jfet16 l=1.2 w=6.0
j2579 769 769 1 0 jfet16 l=1.2 w=6.0
j2580 1 770 770 0 jfet16 l=1.2 w=6.0
j2581 771 771 1 0 jfet16 l=1.2 w=6.0
j2582 772 772 1 0 jfet16 l=1.2 w=3.2
j2583 768 739 0 0 jfet04 l=1.2 w=48.0
j2584 0 739 768 0 jfet04 l=1.2 w=48.0
j2585 769 243 0 0 jfet04 l=1.2 w=48.0
j2586 0 243 769 0 jfet04 l=1.2 w=48.0
j2587 770 768 0 0 jfet04 l=1.2 w=48.0
j2588 0 768 770 0 jfet04 l=1.2 w=48.0
j2589 770 769 0 0 jfet04 l=1.2 w=48.0
j2590 0 769 770 0 jfet04 l=1.2 w=48.0
j2591 771 770 0 0 jfet04 l=1.2 w=48.0
j2592 0 770 771 0 jfet04 l=1.2 w=48.0
j2593 773 771 1 0 jfet04 l=1.2 w=20.0
j2594 0 774 772 0 jfet16 l=1.2 w=10.0
j2595 775 772 1 0 jfet16 l=1.2 w=20.0
j2596 248 776 248 248 dio16 l=1.2 w=10.0
j2597 774 773 774 248 dio16 l=1.2 w=4.0
j2598 774 248 248 0 jfet20 l=3.2 w=3.2

j2599 777 775 777 248 dio16 l=1.2 w=20.0
j2600 776 778 776 248 dio16 l=1.2 w=10.0
j2601 746 779 0 0 jfet04 l=1.2 w=48.0
j2602 0 779 746 0 jfet04 l=1.2 w=48.0
j2603 747 169 0 0 jfet04 l=1.2 w=48.0
j2604 0 169 747 0 jfet04 l=1.2 w=48.0
j2605 748 780 0 0 jfet04 l=1.2 w=48.0
j2606 0 780 748 0 jfet04 l=1.2 w=48.0
j2607 749 781 0 0 jfet04 l=1.2 w=48.0
j2608 0 781 749 0 jfet04 l=1.2 w=48.0
j2609 752 749 0 0 jfet04 l=1.2 w=48.0
j2610 0 749 752 0 jfet04 l=1.2 w=48.0
j2611 752 748 0 0 jfet04 l=1.2 w=48.0
j2612 0 748 752 0 jfet04 l=1.2 w=48.0
j2613 752 747 0 0 jfet04 l=1.2 w=48.0
j2614 0 747 752 0 jfet04 l=1.2 w=48.0
j2615 752 746 0 0 jfet04 l=1.2 w=48.0
j2616 0 746 752 0 jfet04 l=1.2 w=48.0
j2617 753 782 0 0 jfet04 l=1.2 w=48.0
j2618 0 782 753 0 jfet04 l=1.2 w=48.0
j2619 754 783 0 0 jfet04 l=1.2 w=48.0
j2620 0 783 754 0 jfet04 l=1.2 w=48.0
j2621 755 784 0 0 jfet04 l=1.2 w=48.0
j2622 0 784 755 0 jfet04 l=1.2 w=48.0
j2623 756 175 0 0 jfet04 l=1.2 w=48.0
j2624 0 175 756 0 jfet04 l=1.2 w=48.0
j2625 757 756 0 0 jfet04 l=1.2 w=48.0
j2626 0 756 757 0 jfet04 l=1.2 w=48.0
j2627 757 755 0 0 jfet04 l=1.2 w=48.0
j2628 0 755 757 0 jfet04 l=1.2 w=48.0
j2629 757 754 0 0 jfet04 l=1.2 w=48.0
j2630 0 754 757 0 jfet04 l=1.2 w=48.0
j2631 757 753 0 0 jfet04 l=1.2 w=48.0
j2632 0 753 757 0 jfet04 l=1.2 w=48.0
j2633 758 779 0 0 jfet04 l=1.2 w=48.0
j2634 0 779 758 0 jfet04 l=1.2 w=48.0
j2635 759 784 0 0 jfet04 l=1.2 w=48.0
j2636 0 784 759 0 jfet04 l=1.2 w=48.0
j2637 760 175 0 0 jfet04 l=1.2 w=48.0
j2638 0 175 760 0 jfet04 l=1.2 w=48.0
j2639 761 782 0 0 jfet04 l=1.2 w=48.0
j2640 0 782 761 0 jfet04 l=1.2 w=48.0
j2641 762 761 0 0 jfet04 l=1.2 w=48.0
j2642 0 761 762 0 jfet04 l=1.2 w=48.0
j2643 762 760 0 0 jfet04 l=1.2 w=48.0
j2644 0 760 762 0 jfet04 l=1.2 w=48.0
j2645 762 759 0 0 jfet04 l=1.2 w=48.0
j2646 0 759 762 0 jfet04 l=1.2 w=48.0
j2647 762 758 0 0 jfet04 l=1.2 w=48.0
j2648 0 758 762 0 jfet04 l=1.2 w=48.0
j2649 763 779 0 0 jfet04 l=1.2 w=48.0

j2650 0 779 763 0 jfet04 l=1.2 w=48.0
j2651 764 784 0 0 jfet04 l=1.2 w=48.0
j2652 0 784 764 0 jfet04 l=1.2 w=48.0
j2653 765 169 0 0 jfet04 l=1.2 w=48.0
j2654 0 169 765 0 jfet04 l=1.2 w=48.0
j2655 766 781 0 0 jfet04 l=1.2 w=48.0
j2656 0 781 766 0 jfet04 l=1.2 w=48.0
j2657 767 766 0 0 jfet04 l=1.2 w=48.0
j2658 0 766 767 0 jfet04 l=1.2 w=48.0
j2659 767 765 0 0 jfet04 l=1.2 w=48.0
j2660 0 765 767 0 jfet04 l=1.2 w=48.0
j2661 767 764 0 0 jfet04 l=1.2 w=48.0
j2662 0 764 767 0 jfet04 l=1.2 w=48.0
j2663 767 763 0 0 jfet04 l=1.2 w=48.0
j2664 0 763 767 0 jfet04 l=1.2 w=48.0
j2665 248 248 205 0 jfet16 l=1.2 w=12.0
j2666 778 785 778 248 dio16 l=1.2 w=10.0
j2667 785 205 785 248 dio16 l=1.2 w=10.0
j2668 176 177 786 0 jfet16 l=1.2 w=3.2
j2669 205 777 205 248 dio16 l=1.2 w=20.0
j2670 779 179 787 0 jfet16 l=1.2 w=8.0
j2671 788 182 779 0 jfet16 l=1.2 w=8.0
j2672 786 183 779 0 jfet16 l=1.2 w=8.0
j2673 1 720 720 0 jfet16 l=1.2 w=6.0
j2674 721 721 1 0 jfet16 l=1.2 w=6.0
j2675 722 722 1 0 jfet16 l=1.2 w=6.0
j2676 653 653 1 0 jfet16 l=1.2 w=6.0
j2677 723 723 1 0 jfet16 l=1.2 w=6.0
j2678 724 724 1 0 jfet16 l=1.2 w=6.0
j2679 725 725 1 0 jfet16 l=1.2 w=6.0
j2680 726 726 1 0 jfet16 l=1.2 w=6.0
j2681 654 654 1 0 jfet16 l=1.2 w=6.0
j2682 727 727 1 0 jfet16 l=1.2 w=6.0
j2683 728 728 1 0 jfet16 l=1.2 w=6.0
j2684 729 729 1 0 jfet16 l=1.2 w=6.0
j2685 730 730 1 0 jfet16 l=1.2 w=6.0
j2686 473 473 1 0 jfet16 l=1.2 w=6.0
j2687 1 789 779 0 jfet16 l=1.2 w=62.0
j2688 731 731 1 0 jfet16 l=1.2 w=6.0
j2689 732 732 1 0 jfet16 l=1.2 w=6.0
j2690 733 733 1 0 jfet16 l=1.2 w=6.0
j2691 651 651 1 0 jfet16 l=1.2 w=6.0
j2692 185 177 779 0 jfet16 l=1.2 w=6.0
j2693 790 187 779 0 jfet16 l=1.2 w=8.0
j2694 779 789 1 0 jfet16 l=1.2 w=62.0
j2695 1 791 791 0 jfet16 l=1.2 w=6.0
j2696 792 792 1 0 jfet16 l=1.2 w=6.0
j2697 1 793 793 0 jfet16 l=1.2 w=6.0
j2698 1 794 794 0 jfet16 l=1.2 w=6.0
j2699 795 795 1 0 jfet16 l=1.2 w=6.0
j2700 1 796 796 0 jfet16 l=1.2 w=6.0

j2701 1 797 797 0 jfet16 l=1.2 w=6.0
j2702 798 798 1 0 jfet16 l=1.2 w=6.0
j2703 1 799 799 0 jfet16 l=1.2 w=6.0
j2704 1 800 800 0 jfet16 l=1.2 w=6.0
j2705 801 801 1 0 jfet16 l=1.2 w=6.0
j2706 802 802 1 0 jfet16 l=1.2 w=6.0
j2707 803 803 1 0 jfet16 l=1.2 w=6.0
j2708 804 804 1 0 jfet16 l=1.2 w=6.0
j2709 1 805 805 0 jfet16 l=1.2 w=6.0
j2710 806 806 1 0 jfet16 l=1.2 w=6.0
j2711 807 807 1 0 jfet16 l=1.2 w=6.0
j2712 808 808 1 0 jfet16 l=1.2 w=6.0
j2713 809 809 1 0 jfet16 l=1.2 w=6.0
j2714 1 810 810 0 jfet16 l=1.2 w=6.0
j2715 811 811 1 0 jfet16 l=1.2 w=6.0
j2716 812 812 1 0 jfet16 l=1.2 w=6.0
j2717 813 813 1 0 jfet16 l=1.2 w=6.0
j2718 1 814 814 0 jfet16 l=1.2 w=6.0
j2719 815 815 1 0 jfet16 l=1.2 w=6.0
j2720 791 472 0 0 jfet04 l=1.2 w=48.0
j2721 0 472 791 0 jfet04 l=1.2 w=48.0
j2722 792 816 0 0 jfet04 l=1.2 w=48.0
j2723 0 816 792 0 jfet04 l=1.2 w=48.0
j2724 793 791 0 0 jfet04 l=1.2 w=48.0
j2725 0 791 793 0 jfet04 l=1.2 w=48.0
j2726 793 792 0 0 jfet04 l=1.2 w=48.0
j2727 0 792 793 0 jfet04 l=1.2 w=48.0
j2728 794 473 0 0 jfet04 l=1.2 w=48.0
j2729 0 473 794 0 jfet04 l=1.2 w=48.0
j2730 795 816 0 0 jfet04 l=1.2 w=48.0
j2731 0 816 795 0 jfet04 l=1.2 w=48.0
j2732 796 794 0 0 jfet04 l=1.2 w=48.0
j2733 0 794 796 0 jfet04 l=1.2 w=48.0
j2734 796 795 0 0 jfet04 l=1.2 w=48.0
j2735 0 795 796 0 jfet04 l=1.2 w=48.0
j2736 797 513 0 0 jfet04 l=1.2 w=48.0
j2737 0 513 797 0 jfet04 l=1.2 w=48.0
j2738 798 816 0 0 jfet04 l=1.2 w=48.0
j2739 0 816 798 0 jfet04 l=1.2 w=48.0
j2740 799 797 0 0 jfet04 l=1.2 w=48.0
j2741 0 797 799 0 jfet04 l=1.2 w=48.0
j2742 799 798 0 0 jfet04 l=1.2 w=48.0
j2743 0 798 799 0 jfet04 l=1.2 w=48.0
j2744 800 799 0 0 jfet04 l=1.2 w=48.0
j2745 0 799 800 0 jfet04 l=1.2 w=48.0
j2746 800 796 0 0 jfet04 l=1.2 w=48.0
j2747 0 796 800 0 jfet04 l=1.2 w=48.0
j2748 800 793 0 0 jfet04 l=1.2 w=48.0
j2749 0 793 800 0 jfet04 l=1.2 w=48.0
j2750 800 817 0 0 jfet04 l=1.2 w=48.0
j2751 0 817 800 0 jfet04 l=1.2 w=48.0

j2752 801 800 0 0 jfet04 l=1.2 w=48.0
j2753 0 800 801 0 jfet04 l=1.2 w=48.0
j2754 802 801 0 0 jfet04 l=1.2 w=48.0
j2755 0 801 802 0 jfet04 l=1.2 w=48.0
j2756 803 481 0 0 jfet04 l=1.2 w=48.0
j2757 0 481 803 0 jfet04 l=1.2 w=48.0
j2758 804 818 0 0 jfet04 l=1.2 w=48.0
j2759 0 818 804 0 jfet04 l=1.2 w=48.0
j2760 805 804 0 0 jfet04 l=1.2 w=48.0
j2761 0 804 805 0 jfet04 l=1.2 w=48.0
j2762 805 803 0 0 jfet04 l=1.2 w=48.0
j2763 0 803 805 0 jfet04 l=1.2 w=48.0
j2764 805 802 0 0 jfet04 l=1.2 w=48.0
j2765 0 802 805 0 jfet04 l=1.2 w=48.0
j2766 806 805 0 0 jfet04 l=1.2 w=48.0
j2767 0 805 806 0 jfet04 l=1.2 w=48.0
j2768 807 481 0 0 jfet04 l=1.2 w=48.0
j2769 0 481 807 0 jfet04 l=1.2 w=48.0
j2770 808 815 0 0 jfet04 l=1.2 w=48.0
j2771 0 815 808 0 jfet04 l=1.2 w=48.0
j2772 809 297 0 0 jfet04 l=1.2 w=48.0
j2773 0 297 809 0 jfet04 l=1.2 w=48.0
j2774 810 809 0 0 jfet04 l=1.2 w=48.0
j2775 0 809 810 0 jfet04 l=1.2 w=48.0
j2776 810 808 0 0 jfet04 l=1.2 w=48.0
j2777 0 808 810 0 jfet04 l=1.2 w=48.0
j2778 810 807 0 0 jfet04 l=1.2 w=48.0
j2779 0 807 810 0 jfet04 l=1.2 w=48.0
j2780 811 810 0 0 jfet04 l=1.2 w=48.0
j2781 0 810 811 0 jfet04 l=1.2 w=48.0
j2782 812 811 0 0 jfet04 l=1.2 w=48.0
j2783 0 811 812 0 jfet04 l=1.2 w=48.0
j2784 813 806 0 0 jfet04 l=1.2 w=48.0
j2785 0 806 813 0 jfet04 l=1.2 w=48.0
j2786 814 813 0 0 jfet04 l=1.2 w=48.0
j2787 0 813 814 0 jfet04 l=1.2 w=48.0
j2788 814 812 0 0 jfet04 l=1.2 w=48.0
j2789 0 812 814 0 jfet04 l=1.2 w=48.0
j2790 815 814 0 0 jfet04 l=1.2 w=48.0
j2791 0 814 815 0 jfet04 l=1.2 w=48.0
j2792 819 820 0 0 jfet04 l=1.2 w=48.0
j2793 0 820 819 0 jfet04 l=1.2 w=48.0
j2794 821 822 0 0 jfet04 l=1.2 w=48.0
j2795 0 822 821 0 jfet04 l=1.2 w=48.0
j2796 823 595 0 0 jfet04 l=1.2 w=48.0
j2797 0 595 823 0 jfet04 l=1.2 w=48.0
j2798 824 821 0 0 jfet04 l=1.2 w=48.0
j2799 0 821 824 0 jfet04 l=1.2 w=48.0
j2800 824 823 0 0 jfet04 l=1.2 w=48.0
j2801 0 823 824 0 jfet04 l=1.2 w=48.0
j2802 825 822 0 0 jfet04 l=1.2 w=48.0

j2803 0 822 825 0 jfet04 l=1.2 w=48.0
j2804 826 651 0 0 jfet04 l=1.2 w=48.0
j2805 0 651 826 0 jfet04 l=1.2 w=48.0
j2806 827 825 0 0 jfet04 l=1.2 w=48.0
j2807 0 825 827 0 jfet04 l=1.2 w=48.0
j2808 827 826 0 0 jfet04 l=1.2 w=48.0
j2809 0 826 827 0 jfet04 l=1.2 w=48.0
j2810 828 819 0 0 jfet04 l=1.2 w=48.0
j2811 0 819 828 0 jfet04 l=1.2 w=48.0
j2812 829 598 0 0 jfet04 l=1.2 w=48.0
j2813 0 598 829 0 jfet04 l=1.2 w=48.0
j2814 830 651 0 0 jfet04 l=1.2 w=48.0
j2815 0 651 830 0 jfet04 l=1.2 w=48.0
j2816 831 830 0 0 jfet04 l=1.2 w=48.0
j2817 0 830 831 0 jfet04 l=1.2 w=48.0
j2818 831 829 0 0 jfet04 l=1.2 w=48.0
j2819 0 829 831 0 jfet04 l=1.2 w=48.0
j2820 831 828 0 0 jfet04 l=1.2 w=48.0
j2821 0 828 831 0 jfet04 l=1.2 w=48.0
j2822 832 831 0 0 jfet04 l=1.2 w=48.0
j2823 0 831 832 0 jfet04 l=1.2 w=48.0
j2824 832 827 0 0 jfet04 l=1.2 w=48.0
j2825 0 827 832 0 jfet04 l=1.2 w=48.0
j2826 832 824 0 0 jfet04 l=1.2 w=48.0
j2827 0 824 832 0 jfet04 l=1.2 w=48.0
j2828 600 832 0 0 jfet04 l=1.2 w=48.0
j2829 0 832 600 0 jfet04 l=1.2 w=48.0
j2830 0 441 833 0 jfet04 l=1.2 w=48.0
j2831 834 441 0 0 jfet04 l=1.2 w=48.0
j2832 1 833 834 0 jfet04 l=1.2 w=48.0
j2833 835 836 1 0 jfet04 l=1.2 w=48.0
j2834 0 561 835 0 jfet04 l=1.2 w=48.0
j2835 836 561 0 0 jfet04 l=1.2 w=48.0
j2836 0 600 837 0 jfet04 l=1.2 w=48.0
j2837 838 600 0 0 jfet04 l=1.2 w=48.0
j2838 1 837 838 0 jfet04 l=1.2 w=48.0
j2839 839 840 1 0 jfet04 l=1.2 w=48.0
j2840 0 439 839 0 jfet04 l=1.2 w=48.0
j2841 840 439 0 0 jfet04 l=1.2 w=48.0
j2842 0 834 841 0 jfet04 l=1.2 w=48.0
j2843 841 835 0 0 jfet04 l=1.2 w=48.0
j2844 0 838 841 0 jfet04 l=1.2 w=48.0
j2845 841 839 0 0 jfet04 l=1.2 w=48.0
j2846 842 841 1 0 jfet04 l=1.2 w=48.0
j2847 0 839 842 0 jfet04 l=1.2 w=48.0
j2848 842 838 0 0 jfet04 l=1.2 w=48.0
j2849 0 835 842 0 jfet04 l=1.2 w=48.0
j2850 842 834 0 0 jfet04 l=1.2 w=48.0
j2851 843 842 0 0 jfet04 l=1.2 w=48.0
j2852 0 842 843 0 jfet04 l=1.2 w=48.0
j2853 844 243 0 0 jfet04 l=1.2 w=48.0

j2854 0 243 844 0 jfet04 l=1.2 w=48.0
j2855 845 843 0 0 jfet04 l=1.2 w=48.0
j2856 0 843 845 0 jfet04 l=1.2 w=48.0
j2857 845 844 0 0 jfet04 l=1.2 w=48.0
j2858 0 844 845 0 jfet04 l=1.2 w=48.0
j2859 846 845 0 0 jfet04 l=1.2 w=48.0
j2860 0 845 846 0 jfet04 l=1.2 w=48.0
j2861 187 847 187 248 dio16 l=1.2 w=20.0
j2862 848 187 848 248 dio16 l=1.2 w=10.0
j2863 779 188 849 0 jfet16 l=1.2 w=8.0
j2864 1 789 779 0 jfet16 l=1.2 w=62.0
j2865 248 248 850 0 jfet20 l=3.2 w=3.2
j2866 850 851 850 248 dio16 l=1.2 w=4.0
j2867 851 846 1 0 jfet04 l=1.2 w=20.0
j2868 847 852 847 248 dio16 l=1.2 w=20.0
j2869 248 248 187 0 jfet16 l=1.2 w=12.0
j2870 779 853 0 0 jfet04 l=1.2 w=6.0
j2871 779 784 0 0 jfet04 l=1.2 w=70.0
j2872 854 848 854 248 dio16 l=1.2 w=10.0
j2873 0 784 779 0 jfet04 l=1.2 w=70.0
j2874 1 833 833 0 jfet16 l=1.2 w=3.2
j2875 836 836 1 0 jfet16 l=1.2 w=3.2
j2876 1 837 837 0 jfet16 l=1.2 w=3.2
j2877 840 840 1 0 jfet16 l=1.2 w=3.2
j2878 841 841 1 0 jfet16 l=1.2 w=3.2
j2879 1 843 843 0 jfet16 l=1.2 w=6.0
j2880 844 844 1 0 jfet16 l=1.2 w=6.0
j2881 1 845 845 0 jfet16 l=1.2 w=6.0
j2882 846 846 1 0 jfet16 l=1.2 w=6.0
j2883 855 855 1 0 jfet16 l=1.2 w=3.2
j2884 0 850 855 0 jfet16 l=1.2 w=10.0
j2885 852 855 1 0 jfet16 l=1.2 w=20.0
j2886 856 854 856 248 dio16 l=1.2 w=10.0
j2887 1 191 779 0 jfet16 l=1.2 w=9.2
j2888 779 784 0 0 jfet04 l=1.2 w=70.0
j2889 779 177 784 0 jfet16 l=1.2 w=17.2
j2890 0 779 784 0 jfet04 l=1.2 w=70.0
j2891 248 856 248 248 dio16 l=1.2 w=10.0
j2892 784 779 0 0 jfet04 l=1.2 w=70.0
j2893 1 191 784 0 jfet16 l=1.2 w=9.2
j2894 0 857 784 0 jfet04 l=1.2 w=6.0
j2895 0 779 784 0 jfet04 l=1.2 w=70.0
j2896 1 858 858 0 jfet16 l=1.2 w=3.2
j2897 859 859 1 0 jfet16 l=1.2 w=3.2
j2898 1 860 860 0 jfet16 l=1.2 w=3.2
j2899 861 861 1 0 jfet16 l=1.2 w=3.2
j2900 1 862 862 0 jfet16 l=1.2 w=3.2
j2901 819 819 1 0 jfet16 l=1.2 w=6.0
j2902 1 821 821 0 jfet16 l=1.2 w=6.0
j2903 823 823 1 0 jfet16 l=1.2 w=6.0
j2904 1 824 824 0 jfet16 l=1.2 w=6.0

j2905 1 825 825 0 jfet16 l=1.2 w=6.0
j2906 826 826 1 0 jfet16 l=1.2 w=6.0
j2907 1 827 827 0 jfet16 l=1.2 w=6.0
j2908 1 828 828 0 jfet16 l=1.2 w=6.0
j2909 829 829 1 0 jfet16 l=1.2 w=6.0
j2910 830 830 1 0 jfet16 l=1.2 w=6.0
j2911 831 831 1 0 jfet16 l=1.2 w=6.0
j2912 1 832 832 0 jfet16 l=1.2 w=6.0
j2913 600 600 1 0 jfet16 l=1.2 w=6.0
j2914 1 863 863 0 jfet16 l=1.2 w=6.0
j2915 1 864 864 0 jfet16 l=1.2 w=6.0
j2916 865 865 1 0 jfet16 l=1.2 w=6.0
j2917 1 866 866 0 jfet16 l=1.2 w=6.0
j2918 1 867 867 0 jfet16 l=1.2 w=6.0
j2919 868 868 1 0 jfet16 l=1.2 w=6.0
j2920 1 869 869 0 jfet16 l=1.2 w=6.0
j2921 870 651 0 0 jfet04 l=1.2 w=48.0
j2922 0 651 870 0 jfet04 l=1.2 w=48.0
j2923 871 512 0 0 jfet04 l=1.2 w=48.0
j2924 0 512 871 0 jfet04 l=1.2 w=48.0
j2925 872 481 0 0 jfet04 l=1.2 w=48.0
j2926 0 481 872 0 jfet04 l=1.2 w=48.0
j2927 873 467 0 0 jfet04 l=1.2 w=48.0
j2928 0 467 873 0 jfet04 l=1.2 w=48.0
j2929 817 873 0 0 jfet04 l=1.2 w=48.0
j2930 0 873 817 0 jfet04 l=1.2 w=48.0
j2931 817 872 0 0 jfet04 l=1.2 w=48.0
j2932 0 872 817 0 jfet04 l=1.2 w=48.0
j2933 817 871 0 0 jfet04 l=1.2 w=48.0
j2934 0 871 817 0 jfet04 l=1.2 w=48.0
j2935 817 870 0 0 jfet04 l=1.2 w=48.0
j2936 0 870 817 0 jfet04 l=1.2 w=48.0
j2937 874 297 0 0 jfet04 l=1.2 w=48.0
j2938 0 297 874 0 jfet04 l=1.2 w=48.0
j2939 875 811 0 0 jfet04 l=1.2 w=48.0
j2940 0 811 875 0 jfet04 l=1.2 w=48.0
j2941 876 806 0 0 jfet04 l=1.2 w=48.0
j2942 0 806 876 0 jfet04 l=1.2 w=48.0
j2943 877 876 0 0 jfet04 l=1.2 w=48.0
j2944 0 876 877 0 jfet04 l=1.2 w=48.0
j2945 877 875 0 0 jfet04 l=1.2 w=48.0
j2946 0 875 877 0 jfet04 l=1.2 w=48.0
j2947 877 874 0 0 jfet04 l=1.2 w=48.0
j2948 0 874 877 0 jfet04 l=1.2 w=48.0
j2949 818 877 0 0 jfet04 l=1.2 w=48.0
j2950 0 877 818 0 jfet04 l=1.2 w=48.0
j2951 878 481 0 0 jfet04 l=1.2 w=48.0
j2952 0 481 878 0 jfet04 l=1.2 w=48.0
j2953 879 816 0 0 jfet04 l=1.2 w=48.0
j2954 0 816 879 0 jfet04 l=1.2 w=48.0
j2955 880 818 0 0 jfet04 l=1.2 w=48.0

j2956 0 818 880 0 jfet04 l=1.2 w=48.0
j2957 881 880 0 0 jfet04 l=1.2 w=48.0
j2958 0 880 881 0 jfet04 l=1.2 w=48.0
j2959 881 879 0 0 jfet04 l=1.2 w=48.0
j2960 0 879 881 0 jfet04 l=1.2 w=48.0
j2961 881 878 0 0 jfet04 l=1.2 w=48.0
j2962 0 878 881 0 jfet04 l=1.2 w=48.0
j2963 467 881 0 0 jfet04 l=1.2 w=48.0
j2964 0 881 467 0 jfet04 l=1.2 w=48.0
j2965 882 467 0 0 jfet04 l=1.2 w=48.0
j2966 0 467 882 0 jfet04 l=1.2 w=48.0
j2967 883 811 0 0 jfet04 l=1.2 w=48.0
j2968 0 811 883 0 jfet04 l=1.2 w=48.0
j2969 884 883 0 0 jfet04 l=1.2 w=48.0
j2970 0 883 884 0 jfet04 l=1.2 w=48.0
j2971 884 882 0 0 jfet04 l=1.2 w=48.0
j2972 0 882 884 0 jfet04 l=1.2 w=48.0
j2973 816 884 0 0 jfet04 l=1.2 w=48.0
j2974 0 884 816 0 jfet04 l=1.2 w=48.0
j2975 1 885 885 0 jfet16 l=1.2 w=6.0
j2976 886 886 1 0 jfet16 l=1.2 w=6.0
j2977 887 887 1 0 jfet16 l=1.2 w=6.0
j2978 888 888 1 0 jfet16 l=1.2 w=6.0
j2979 1 889 889 0 jfet16 l=1.2 w=6.0
j2980 599 599 1 0 jfet16 l=1.2 w=6.0
j2981 0 441 858 0 jfet04 l=1.2 w=48.0
j2982 890 441 0 0 jfet04 l=1.2 w=48.0
j2983 1 858 890 0 jfet04 l=1.2 w=48.0
j2984 891 859 1 0 jfet04 l=1.2 w=48.0
j2985 0 562 891 0 jfet04 l=1.2 w=48.0
j2986 859 562 0 0 jfet04 l=1.2 w=48.0
j2987 0 599 860 0 jfet04 l=1.2 w=48.0
j2988 892 599 0 0 jfet04 l=1.2 w=48.0
j2989 1 860 892 0 jfet04 l=1.2 w=48.0
j2990 1 893 893 0 jfet16 l=1.2 w=6.0
j2991 894 894 1 0 jfet16 l=1.2 w=6.0
j2992 895 861 1 0 jfet04 l=1.2 w=48.0
j2993 0 563 895 0 jfet04 l=1.2 w=48.0
j2994 861 563 0 0 jfet04 l=1.2 w=48.0
j2995 0 890 862 0 jfet04 l=1.2 w=48.0
j2996 862 891 0 0 jfet04 l=1.2 w=48.0
j2997 0 892 862 0 jfet04 l=1.2 w=48.0
j2998 862 895 0 0 jfet04 l=1.2 w=48.0
j2999 896 862 1 0 jfet04 l=1.2 w=48.0
j3000 0 895 896 0 jfet04 l=1.2 w=48.0
j3001 896 892 0 0 jfet04 l=1.2 w=48.0
j3002 0 891 896 0 jfet04 l=1.2 w=48.0
j3003 896 890 0 0 jfet04 l=1.2 w=48.0
j3004 1 897 897 0 jfet16 l=1.2 w=6.0
j3005 898 898 1 0 jfet16 l=1.2 w=6.0
j3006 899 899 1 0 jfet16 l=1.2 w=3.2

j3007 1 870 870 0 jfet16 l=1.2 w=6.0
j3008 871 871 1 0 jfet16 l=1.2 w=6.0
j3009 1 872 872 0 jfet16 l=1.2 w=6.0
j3010 873 873 1 0 jfet16 l=1.2 w=6.0
j3011 877 877 1 0 jfet16 l=1.2 w=6.0
j3012 874 874 1 0 jfet16 l=1.2 w=6.0
j3013 875 875 1 0 jfet16 l=1.2 w=6.0
j3014 876 876 1 0 jfet16 l=1.2 w=6.0
j3015 877 877 1 0 jfet16 l=1.2 w=6.0
j3016 818 818 1 0 jfet16 l=1.2 w=6.0
j3017 878 878 1 0 jfet16 l=1.2 w=6.0
j3018 879 879 1 0 jfet16 l=1.2 w=6.0
j3019 880 880 1 0 jfet16 l=1.2 w=6.0
j3020 881 881 1 0 jfet16 l=1.2 w=6.0
j3021 467 467 1 0 jfet16 l=1.2 w=6.0
j3022 863 900 0 0 jfet04 l=1.2 w=48.0
j3023 0 900 863 0 jfet04 l=1.2 w=48.0
j3024 864 901 0 0 jfet04 l=1.2 w=48.0
j3025 0 901 864 0 jfet04 l=1.2 w=48.0
j3026 865 595 0 0 jfet04 l=1.2 w=48.0
j3027 0 595 865 0 jfet04 l=1.2 w=48.0
j3028 866 864 0 0 jfet04 l=1.2 w=48.0
j3029 0 864 866 0 jfet04 l=1.2 w=48.0
j3030 866 865 0 0 jfet04 l=1.2 w=48.0
j3031 0 865 866 0 jfet04 l=1.2 w=48.0
j3032 867 901 0 0 jfet04 l=1.2 w=48.0
j3033 0 901 867 0 jfet04 l=1.2 w=48.0
j3034 868 816 0 0 jfet04 l=1.2 w=48.0
j3035 0 816 868 0 jfet04 l=1.2 w=48.0
j3036 869 867 0 0 jfet04 l=1.2 w=48.0
j3037 0 867 869 0 jfet04 l=1.2 w=48.0
j3038 869 868 0 0 jfet04 l=1.2 w=48.0
j3039 0 868 869 0 jfet04 l=1.2 w=48.0
j3040 885 598 0 0 jfet04 l=1.2 w=48.0
j3041 0 598 885 0 jfet04 l=1.2 w=48.0
j3042 886 863 0 0 jfet04 l=1.2 w=48.0
j3043 0 863 886 0 jfet04 l=1.2 w=48.0
j3044 887 816 0 0 jfet04 l=1.2 w=48.0
j3045 0 816 887 0 jfet04 l=1.2 w=48.0
j3046 888 887 0 0 jfet04 l=1.2 w=48.0
j3047 0 887 888 0 jfet04 l=1.2 w=48.0
j3048 888 886 0 0 jfet04 l=1.2 w=48.0
j3049 0 886 888 0 jfet04 l=1.2 w=48.0
j3050 888 885 0 0 jfet04 l=1.2 w=48.0
j3051 0 885 888 0 jfet04 l=1.2 w=48.0
j3052 889 888 0 0 jfet04 l=1.2 w=48.0
j3053 0 888 889 0 jfet04 l=1.2 w=48.0
j3054 889 869 0 0 jfet04 l=1.2 w=48.0
j3055 0 869 889 0 jfet04 l=1.2 w=48.0
j3056 889 866 0 0 jfet04 l=1.2 w=48.0
j3057 0 866 889 0 jfet04 l=1.2 w=48.0

j3058 599 889 0 0 jfet04 l=1.2 w=48.0
j3059 0 889 599 0 jfet04 l=1.2 w=48.0
j3060 893 896 0 0 jfet04 l=1.2 w=48.0
j3061 0 896 893 0 jfet04 l=1.2 w=48.0
j3062 894 243 0 0 jfet04 l=1.2 w=48.0
j3063 0 243 894 0 jfet04 l=1.2 w=48.0
j3064 897 893 0 0 jfet04 l=1.2 w=48.0
j3065 0 893 897 0 jfet04 l=1.2 w=48.0
j3066 897 894 0 0 jfet04 l=1.2 w=48.0
j3067 0 894 897 0 jfet04 l=1.2 w=48.0
j3068 898 897 0 0 jfet04 l=1.2 w=48.0
j3069 0 897 898 0 jfet04 l=1.2 w=48.0
j3070 902 898 1 0 jfet04 l=1.2 w=20.0
j3071 0 903 899 0 jfet16 l=1.2 w=10.0
j3072 904 899 1 0 jfet16 l=1.2 w=20.0
j3073 248 905 248 248 dio16 l=1.2 w=10.0
j3074 906 194 784 0 jfet16 l=1.2 w=8.0
j3075 784 907 1 0 jfet16 l=1.2 w=62.0
j3076 908 752 0 0 jfet04 l=1.2 w=48.0
j3077 0 752 908 0 jfet04 l=1.2 w=48.0
j3078 908 757 0 0 jfet04 l=1.2 w=48.0
j3079 0 757 908 0 jfet04 l=1.2 w=48.0
j3080 908 762 0 0 jfet04 l=1.2 w=48.0
j3081 0 762 908 0 jfet04 l=1.2 w=48.0
j3082 908 767 0 0 jfet04 l=1.2 w=48.0
j3083 0 767 908 0 jfet04 l=1.2 w=48.0
j3084 909 908 0 0 jfet04 l=1.2 w=48.0
j3085 0 908 909 0 jfet04 l=1.2 w=48.0
j3086 783 779 0 0 jfet04 l=1.2 w=48.0
j3087 0 779 783 0 jfet04 l=1.2 w=48.0
j3088 780 784 0 0 jfet04 l=1.2 w=48.0
j3089 0 784 780 0 jfet04 l=1.2 w=48.0
j3090 781 175 0 0 jfet04 l=1.2 w=48.0
j3091 0 175 781 0 jfet04 l=1.2 w=48.0
j3092 782 169 0 0 jfet04 l=1.2 w=48.0
j3093 0 169 782 0 jfet04 l=1.2 w=48.0
j3094 910 169 0 0 jfet04 l=1.2 w=48.0
j3095 0 169 910 0 jfet04 l=1.2 w=48.0
j3096 910 175 0 0 jfet04 l=1.2 w=48.0
j3097 0 175 910 0 jfet04 l=1.2 w=48.0
j3098 911 910 0 0 jfet04 l=1.2 w=48.0
j3099 0 910 911 0 jfet04 l=1.2 w=48.0
j3100 912 911 0 0 jfet04 l=1.2 w=48.0
j3101 0 911 912 0 jfet04 l=1.2 w=48.0
j3102 913 202 0 0 jfet04 l=1.2 w=48.0
j3103 0 202 913 0 jfet04 l=1.2 w=48.0
j3104 914 912 0 0 jfet04 l=1.2 w=48.0
j3105 0 912 914 0 jfet04 l=1.2 w=48.0
j3106 914 913 0 0 jfet04 l=1.2 w=48.0
j3107 0 913 914 0 jfet04 l=1.2 w=48.0
j3108 915 909 0 0 jfet04 l=1.2 w=48.0

j3109 0 909 915 0 jfet04 l=1.2 w=48.0
j3110 784 205 916 0 jfet16 l=1.2 w=8.0
j3111 1 907 784 0 jfet16 l=1.2 w=62.0
j3112 903 902 903 248 dio16 l=1.2 w=4.0
j3113 903 248 248 0 jfet20 l=3.2 w=3.2
j3114 917 904 917 248 dio16 l=1.2 w=20.0
j3115 905 918 905 248 dio16 l=1.2 w=10.0
j3116 185 177 784 0 jfet16 l=1.2 w=6.0
j3117 1 908 908 0 jfet16 l=1.2 w=6.0
j3118 909 909 1 0 jfet16 l=1.2 w=6.0
j3119 1 783 783 0 jfet16 l=1.2 w=6.0
j3120 780 780 1 0 jfet16 l=1.2 w=6.0
j3121 1 781 781 0 jfet16 l=1.2 w=6.0
j3122 782 782 1 0 jfet16 l=1.2 w=6.0
j3123 1 910 910 0 jfet16 l=1.2 w=6.0
j3124 911 911 1 0 jfet16 l=1.2 w=6.0
j3125 1 912 912 0 jfet16 l=1.2 w=6.0
j3126 913 913 1 0 jfet16 l=1.2 w=6.0
j3127 1 914 914 0 jfet16 l=1.2 w=6.0
j3128 915 915 1 0 jfet16 l=1.2 w=6.0
j3129 919 909 0 0 jfet04 l=1.2 w=64.0
j3130 0 909 919 0 jfet04 l=1.2 w=64.0
j3131 919 909 0 0 jfet04 l=1.2 w=64.0
j3132 920 914 919 0 jfet04 l=1.2 w=64.0
j3133 919 914 920 0 jfet04 l=1.2 w=64.0
j3134 920 914 919 0 jfet04 l=1.2 w=64.0
j3135 921 920 117 0 jfet04 l=1.2 w=64.0
j3136 117 920 921 0 jfet04 l=1.2 w=64.0
j3137 921 920 117 0 jfet04 l=1.2 w=64.0
j3138 0 922 921 0 jfet04 l=1.2 w=64.0
j3139 921 922 0 0 jfet04 l=1.2 w=64.0
j3140 0 922 921 0 jfet04 l=1.2 w=64.0
j3141 923 914 0 0 jfet04 l=1.2 w=64.0
j3142 0 914 923 0 jfet04 l=1.2 w=64.0
j3143 923 914 0 0 jfet04 l=1.2 w=64.0
j3144 924 915 923 0 jfet04 l=1.2 w=64.0
j3145 923 915 924 0 jfet04 l=1.2 w=64.0
j3146 924 915 923 0 jfet04 l=1.2 w=64.0
j3147 925 924 922 0 jfet04 l=1.2 w=64.0
j3148 922 924 925 0 jfet04 l=1.2 w=64.0
j3149 925 924 922 0 jfet04 l=1.2 w=64.0
j3150 0 117 925 0 jfet04 l=1.2 w=64.0
j3151 925 117 0 0 jfet04 l=1.2 w=64.0
j3152 0 117 925 0 jfet04 l=1.2 w=64.0
j3153 784 907 1 0 jfet16 l=1.2 w=62.0
j3154 784 214 926 0 jfet16 l=1.2 w=8.0
j3155 927 217 784 0 jfet16 l=1.2 w=8.0
j3156 248 248 214 0 jfet16 l=1.2 w=12.0
j3157 918 928 918 248 dio16 l=1.2 w=10.0
j3158 929 219 784 0 jfet16 l=1.2 w=8.0
j3159 1 930 930 0 jfet16 l=1.2 w=6.0

j3160 1 931 931 0 jfet16 l=1.2 w=6.0
j3161 1 932 932 0 jfet16 l=1.2 w=6.0
j3162 1 933 933 0 jfet16 l=1.2 w=6.0
j3163 920 920 1 0 jfet16 l=1.2 w=6.0
j3164 117 117 1 0 jfet16 l=1.2 w=6.0
j3165 924 924 1 0 jfet16 l=1.2 w=6.0
j3166 922 922 1 0 jfet16 l=1.2 w=6.0
j3167 176 177 929 0 jfet16 l=1.2 w=3.2
j3168 928 214 928 248 dio16 l=1.2 w=10.0
j3169 934 934 1 0 jfet16 l=1.2 w=6.0
j3170 214 917 214 248 dio16 l=1.2 w=20.0
j3171 882 882 1 0 jfet16 l=1.2 w=6.0
j3172 883 883 1 0 jfet16 l=1.2 w=6.0
j3173 884 884 1 0 jfet16 l=1.2 w=6.0
j3174 816 816 1 0 jfet16 l=1.2 w=6.0
j3175 1 935 935 0 jfet16 l=1.2 w=6.0
j3176 109 109 1 0 jfet16 l=1.2 w=6.0
j3177 1 936 936 0 jfet16 l=1.2 w=6.0
j3178 937 937 1 0 jfet16 l=1.2 w=6.0
j3179 1 938 938 0 jfet16 l=1.2 w=6.0
j3180 939 939 1 0 jfet16 l=1.2 w=6.0
j3181 1 244 244 0 jfet16 l=1.2 w=6.0
j3182 1 940 940 0 jfet16 l=1.2 w=6.0
j3183 941 941 1 0 jfet16 l=1.2 w=6.0
j3184 942 942 1 0 jfet16 l=1.2 w=6.0
j3185 202 202 1 0 jfet16 l=1.2 w=6.0
j3186 0 441 943 0 jfet04 l=1.2 w=48.0
j3187 944 441 0 0 jfet04 l=1.2 w=48.0
j3188 1 943 944 0 jfet04 l=1.2 w=48.0
j3189 945 946 1 0 jfet04 l=1.2 w=48.0
j3190 0 562 945 0 jfet04 l=1.2 w=48.0
j3191 946 562 0 0 jfet04 l=1.2 w=48.0
j3192 0 599 947 0 jfet04 l=1.2 w=48.0
j3193 948 599 0 0 jfet04 l=1.2 w=48.0
j3194 1 947 948 0 jfet04 l=1.2 w=48.0
j3195 949 950 1 0 jfet04 l=1.2 w=48.0
j3196 0 439 949 0 jfet04 l=1.2 w=48.0
j3197 950 439 0 0 jfet04 l=1.2 w=48.0
j3198 0 944 951 0 jfet04 l=1.2 w=48.0
j3199 951 945 0 0 jfet04 l=1.2 w=48.0
j3200 0 948 951 0 jfet04 l=1.2 w=48.0
j3201 951 949 0 0 jfet04 l=1.2 w=48.0
j3202 952 951 1 0 jfet04 l=1.2 w=48.0
j3203 0 949 952 0 jfet04 l=1.2 w=48.0
j3204 952 948 0 0 jfet04 l=1.2 w=48.0
j3205 0 945 952 0 jfet04 l=1.2 w=48.0
j3206 952 944 0 0 jfet04 l=1.2 w=48.0
j3207 953 952 0 0 jfet04 l=1.2 w=48.0
j3208 0 952 953 0 jfet04 l=1.2 w=48.0
j3209 954 243 0 0 jfet04 l=1.2 w=48.0
j3210 0 243 954 0 jfet04 l=1.2 w=48.0

j3211 955 953 0 0 jfet04 l=1.2 w=48.0
j3212 0 953 955 0 jfet04 l=1.2 w=48.0
j3213 955 954 0 0 jfet04 l=1.2 w=48.0
j3214 0 954 955 0 jfet04 l=1.2 w=48.0
j3215 956 955 0 0 jfet04 l=1.2 w=48.0
j3216 0 955 956 0 jfet04 l=1.2 w=48.0
j3217 179 957 179 248 dio16 l=1.2 w=20.0
j3218 958 179 958 248 dio16 l=1.2 w=10.0
j3219 248 248 959 0 jfet20 l=3.2 w=3.2
j3220 959 960 959 248 dio16 l=1.2 w=4.0
j3221 960 956 1 0 jfet04 l=1.2 w=20.0
j3222 957 961 957 248 dio16 l=1.2 w=20.0
j3223 248 248 179 0 jfet16 l=1.2 w=12.0
j3224 962 958 962 248 dio16 l=1.2 w=10.0
j3225 1 953 953 0 jfet16 l=1.2 w=6.0
j3226 954 954 1 0 jfet16 l=1.2 w=6.0
j3227 1 955 955 0 jfet16 l=1.2 w=6.0
j3228 956 956 1 0 jfet16 l=1.2 w=6.0
j3229 963 963 1 0 jfet16 l=1.2 w=3.2
j3230 0 959 963 0 jfet16 l=1.2 w=10.0
j3231 961 963 1 0 jfet16 l=1.2 w=20.0
j3232 964 962 964 248 dio16 l=1.2 w=10.0
j3233 934 965 0 0 jfet04 l=1.2 w=48.0
j3234 0 965 934 0 jfet04 l=1.2 w=48.0
j3235 966 965 0 0 jfet04 l=1.2 w=64.0
j3236 0 965 966 0 jfet04 l=1.2 w=64.0
j3237 966 965 0 0 jfet04 l=1.2 w=64.0
j3238 930 227 966 0 jfet04 l=1.2 w=64.0
j3239 966 227 930 0 jfet04 l=1.2 w=64.0
j3240 930 227 966 0 jfet04 l=1.2 w=64.0
j3241 967 930 931 0 jfet04 l=1.2 w=64.0
j3242 931 930 967 0 jfet04 l=1.2 w=64.0
j3243 967 930 931 0 jfet04 l=1.2 w=64.0
j3244 0 933 967 0 jfet04 l=1.2 w=64.0
j3245 967 933 0 0 jfet04 l=1.2 w=64.0
j3246 0 933 967 0 jfet04 l=1.2 w=64.0
j3247 968 227 0 0 jfet04 l=1.2 w=64.0
j3248 0 227 968 0 jfet04 l=1.2 w=64.0
j3249 968 227 0 0 jfet04 l=1.2 w=64.0
j3250 932 934 968 0 jfet04 l=1.2 w=64.0
j3251 968 934 932 0 jfet04 l=1.2 w=64.0
j3252 932 934 968 0 jfet04 l=1.2 w=64.0
j3253 969 932 933 0 jfet04 l=1.2 w=64.0
j3254 933 932 969 0 jfet04 l=1.2 w=64.0
j3255 969 932 933 0 jfet04 l=1.2 w=64.0
j3256 0 931 969 0 jfet04 l=1.2 w=64.0
j3257 969 931 0 0 jfet04 l=1.2 w=64.0
j3258 0 931 969 0 jfet04 l=1.2 w=64.0
j3259 1 970 970 0 jfet16 l=1.2 w=6.0
j3260 971 971 1 0 jfet16 l=1.2 w=6.0
j3261 1 972 972 0 jfet16 l=1.2 w=6.0

j3262 973 973 1 0 jfet16 l=1.2 w=6.0
j3263 1 857 857 0 jfet16 l=1.2 w=6.0
j3264 1 974 974 0 jfet16 l=1.2 w=6.0
j3265 975 975 1 0 jfet16 l=1.2 w=6.0
j3266 1 976 976 0 jfet16 l=1.2 w=6.0
j3267 977 977 1 0 jfet16 l=1.2 w=6.0
j3268 1 978 978 0 jfet16 l=1.2 w=6.0
j3269 979 979 1 0 jfet16 l=1.2 w=6.0
j3270 980 980 1 0 jfet16 l=1.2 w=3.2
j3271 970 981 0 0 jfet04 l=1.2 w=48.0
j3272 0 981 970 0 jfet04 l=1.2 w=48.0
j3273 971 933 0 0 jfet04 l=1.2 w=48.0
j3274 0 933 971 0 jfet04 l=1.2 w=48.0
j3275 972 243 0 0 jfet04 l=1.2 w=48.0
j3276 0 243 972 0 jfet04 l=1.2 w=48.0
j3277 973 244 0 0 jfet04 l=1.2 w=48.0
j3278 0 244 973 0 jfet04 l=1.2 w=48.0
j3279 857 973 0 0 jfet04 l=1.2 w=48.0
j3280 0 973 857 0 jfet04 l=1.2 w=48.0
j3281 857 972 0 0 jfet04 l=1.2 w=48.0
j3282 0 972 857 0 jfet04 l=1.2 w=48.0
j3283 857 971 0 0 jfet04 l=1.2 w=48.0
j3284 0 971 857 0 jfet04 l=1.2 w=48.0
j3285 857 970 0 0 jfet04 l=1.2 w=48.0
j3286 0 970 857 0 jfet04 l=1.2 w=48.0
j3287 974 981 0 0 jfet04 l=1.2 w=48.0
j3288 0 981 974 0 jfet04 l=1.2 w=48.0
j3289 975 931 0 0 jfet04 l=1.2 w=48.0
j3290 0 931 975 0 jfet04 l=1.2 w=48.0
j3291 976 244 0 0 jfet04 l=1.2 w=48.0
j3292 0 244 976 0 jfet04 l=1.2 w=48.0
j3293 977 243 0 0 jfet04 l=1.2 w=48.0
j3294 0 243 977 0 jfet04 l=1.2 w=48.0
j3295 978 977 0 0 jfet04 l=1.2 w=48.0
j3296 0 977 978 0 jfet04 l=1.2 w=48.0
j3297 978 976 0 0 jfet04 l=1.2 w=48.0
j3298 0 976 978 0 jfet04 l=1.2 w=48.0
j3299 978 975 0 0 jfet04 l=1.2 w=48.0
j3300 0 975 978 0 jfet04 l=1.2 w=48.0
j3301 978 974 0 0 jfet04 l=1.2 w=48.0
j3302 0 974 978 0 jfet04 l=1.2 w=48.0
j3303 979 978 0 0 jfet04 l=1.2 w=48.0
j3304 0 978 979 0 jfet04 l=1.2 w=48.0
j3305 982 979 1 0 jfet04 l=1.2 w=20.0
j3306 0 983 980 0 jfet16 l=1.2 w=10.0
j3307 984 980 1 0 jfet16 l=1.2 w=20.0
j3308 248 985 248 248 dio16 l=1.2 w=10.0
j3309 983 982 983 248 dio16 l=1.2 w=4.0
j3310 983 248 248 0 jfet20 l=3.2 w=3.2
j3311 986 984 986 248 dio16 l=1.2 w=20.0
j3312 985 987 985 248 dio16 l=1.2 w=10.0

j3313 248 248 907 0 jfet16 l=1.2 w=12.0
j3314 987 988 987 248 dio16 l=1.2 w=10.0
j3315 988 907 988 248 dio16 l=1.2 w=10.0
j3316 907 986 907 248 dio16 l=1.2 w=20.0
j3317 248 964 248 248 dio16 l=1.2 w=10.0
j3318 1 989 989 0 jfet16 l=1.2 w=6.0
j3319 990 990 1 0 jfet16 l=1.2 w=6.0
j3320 1 991 991 0 jfet16 l=1.2 w=6.0
j3321 935 202 0 0 jfet04 l=1.2 w=48.0
j3322 0 202 935 0 jfet04 l=1.2 w=48.0
j3323 935 244 0 0 jfet04 l=1.2 w=48.0
j3324 0 244 935 0 jfet04 l=1.2 w=48.0
j3325 935 598 0 0 jfet04 l=1.2 w=48.0
j3326 0 598 935 0 jfet04 l=1.2 w=48.0
j3327 109 935 0 0 jfet04 l=1.2 w=48.0
j3328 0 935 109 0 jfet04 l=1.2 w=48.0
j3329 936 598 0 0 jfet04 l=1.2 w=48.0
j3330 0 598 936 0 jfet04 l=1.2 w=48.0
j3331 937 992 0 0 jfet04 l=1.2 w=48.0
j3332 0 992 937 0 jfet04 l=1.2 w=48.0
j3333 938 936 0 0 jfet04 l=1.2 w=48.0
j3334 0 936 938 0 jfet04 l=1.2 w=48.0
j3335 939 992 0 0 jfet04 l=1.2 w=48.0
j3336 0 992 939 0 jfet04 l=1.2 w=48.0
j3337 244 938 0 0 jfet04 l=1.2 w=48.0
j3338 0 938 244 0 jfet04 l=1.2 w=48.0
j3339 244 939 0 0 jfet04 l=1.2 w=48.0
j3340 0 939 244 0 jfet04 l=1.2 w=48.0
j3341 940 936 0 0 jfet04 l=1.2 w=48.0
j3342 0 936 940 0 jfet04 l=1.2 w=48.0
j3343 941 937 0 0 jfet04 l=1.2 w=48.0
j3344 0 937 941 0 jfet04 l=1.2 w=48.0
j3345 942 993 0 0 jfet04 l=1.2 w=48.0
j3346 0 993 942 0 jfet04 l=1.2 w=48.0
j3347 202 942 0 0 jfet04 l=1.2 w=48.0
j3348 0 942 202 0 jfet04 l=1.2 w=48.0
j3349 202 941 0 0 jfet04 l=1.2 w=48.0
j3350 0 941 202 0 jfet04 l=1.2 w=48.0
j3351 202 940 0 0 jfet04 l=1.2 w=48.0
j3352 0 940 202 0 jfet04 l=1.2 w=48.0
j3353 1 943 943 0 jfet16 l=1.2 w=3.2
j3354 946 946 1 0 jfet16 l=1.2 w=3.2
j3355 1 947 947 0 jfet16 l=1.2 w=3.2
j3356 950 950 1 0 jfet16 l=1.2 w=3.2
j3357 994 994 1 0 jfet16 l=1.2 w=6.0
j3358 995 995 1 0 jfet16 l=1.2 w=3.2
j3359 951 951 1 0 jfet16 l=1.2 w=3.2
j3360 1 996 996 0 jfet16 l=1.2 w=3.2
j3361 997 997 1 0 jfet16 l=1.2 w=3.2
j3362 1 998 998 0 jfet16 l=1.2 w=3.2
j3363 999 999 1 0 jfet16 l=1.2 w=3.2

j3364 1 1000 1000 0 jfet16 l=1.2 w=3.2
j3365 0 441 996 0 jfet04 l=1.2 w=48.0
j3366 1001 441 0 0 jfet04 l=1.2 w=48.0
j3367 1 996 1001 0 jfet04 l=1.2 w=48.0
j3368 1002 997 1 0 jfet04 l=1.2 w=48.0
j3369 0 600 1002 0 jfet04 l=1.2 w=48.0
j3370 997 600 0 0 jfet04 l=1.2 w=48.0
j3371 0 599 998 0 jfet04 l=1.2 w=48.0
j3372 1003 599 0 0 jfet04 l=1.2 w=48.0
j3373 1 998 1003 0 jfet04 l=1.2 w=48.0
j3374 1004 999 1 0 jfet04 l=1.2 w=48.0
j3375 0 563 1004 0 jfet04 l=1.2 w=48.0
j3376 999 563 0 0 jfet04 l=1.2 w=48.0
j3377 0 1001 1000 0 jfet04 l=1.2 w=48.0
j3378 1000 1002 0 0 jfet04 l=1.2 w=48.0
j3379 0 1003 1000 0 jfet04 l=1.2 w=48.0
j3380 1000 1004 0 0 jfet04 l=1.2 w=48.0
j3381 1005 1000 1 0 jfet04 l=1.2 w=48.0
j3382 0 1004 1005 0 jfet04 l=1.2 w=48.0
j3383 1005 1003 0 0 jfet04 l=1.2 w=48.0
j3384 0 1002 1005 0 jfet04 l=1.2 w=48.0
j3385 1005 1001 0 0 jfet04 l=1.2 w=48.0
j3386 989 1005 0 0 jfet04 l=1.2 w=48.0
j3387 0 1005 989 0 jfet04 l=1.2 w=48.0
j3388 990 243 0 0 jfet04 l=1.2 w=48.0
j3389 0 243 990 0 jfet04 l=1.2 w=48.0
j3390 991 989 0 0 jfet04 l=1.2 w=48.0
j3391 0 989 991 0 jfet04 l=1.2 w=48.0
j3392 991 990 0 0 jfet04 l=1.2 w=48.0
j3393 0 990 991 0 jfet04 l=1.2 w=48.0
j3394 994 991 0 0 jfet04 l=1.2 w=48.0
j3395 0 991 994 0 jfet04 l=1.2 w=48.0
j3396 1006 994 1 0 jfet04 l=1.2 w=20.0
j3397 0 1007 995 0 jfet16 l=1.2 w=10.0
j3398 1008 995 1 0 jfet16 l=1.2 w=20.0
j3399 248 1009 248 248 dio16 l=1.2 w=10.0
j3400 1007 1006 1007 248 dio16 l=1.2 w=4.0
j3401 1007 248 248 0 jfet20 l=3.2 w=3.2
j3402 1010 1008 1010 248 dio16 l=1.2 w=20.0
j3403 1009 1011 1009 248 dio16 l=1.2 w=10.0
j3404 248 248 217 0 jfet16 l=1.2 w=12.0
j3405 1011 1012 1011 248 dio16 l=1.2 w=10.0
j3406 1012 217 1012 248 dio16 l=1.2 w=10.0
j3407 217 1010 217 248 dio16 l=1.2 w=20.0
j3408 1013 1014 0 0 jfet04 l=1.2 w=48.0
j3409 0 1014 1013 0 jfet04 l=1.2 w=48.0
j3410 1015 243 0 0 jfet04 l=1.2 w=48.0
j3411 0 243 1015 0 jfet04 l=1.2 w=48.0
j3412 1016 1013 0 0 jfet04 l=1.2 w=48.0
j3413 0 1013 1016 0 jfet04 l=1.2 w=48.0
j3414 1016 1015 0 0 jfet04 l=1.2 w=48.0

j3415 0 1015 1016 0 jfet04 l=1.2 w=48.0
j3416 1017 1016 0 0 jfet04 l=1.2 w=48.0
j3417 0 1016 1017 0 jfet04 l=1.2 w=48.0
j3418 182 1018 182 248 dio16 l=1.2 w=20.0
j3419 1019 182 1019 248 dio16 l=1.2 w=10.0
j3420 101 1020 0 0 jfet04 l=1.2 w=48.0
j3421 0 1020 101 0 jfet04 l=1.2 w=48.0
j3422 1020 1021 0 0 jfet04 l=1.2 w=48.0
j3423 0 1021 1020 0 jfet04 l=1.2 w=48.0
j3424 1020 1022 0 0 jfet04 l=1.2 w=48.0
j3425 0 1022 1020 0 jfet04 l=1.2 w=48.0
j3426 1021 202 0 0 jfet04 l=1.2 w=48.0
j3427 0 202 1021 0 jfet04 l=1.2 w=48.0
j3428 1022 1023 0 0 jfet04 l=1.2 w=48.0
j3429 0 1023 1022 0 jfet04 l=1.2 w=48.0
j3430 1023 1024 0 0 jfet04 l=1.2 w=48.0
j3431 0 1024 1023 0 jfet04 l=1.2 w=48.0
j3432 1024 169 0 0 jfet04 l=1.2 w=48.0
j3433 0 169 1024 0 jfet04 l=1.2 w=48.0
j3434 1024 175 0 0 jfet04 l=1.2 w=48.0
j3435 0 175 1024 0 jfet04 l=1.2 w=48.0
j3436 981 253 0 0 jfet04 l=1.2 w=48.0
j3437 0 253 981 0 jfet04 l=1.2 w=48.0
j3438 1025 253 0 0 jfet04 l=1.2 w=48.0
j3439 0 253 1025 0 jfet04 l=1.2 w=48.0
j3440 1026 933 0 0 jfet04 l=1.2 w=48.0
j3441 0 933 1026 0 jfet04 l=1.2 w=48.0
j3442 1027 243 0 0 jfet04 l=1.2 w=48.0
j3443 0 243 1027 0 jfet04 l=1.2 w=48.0
j3444 1028 244 0 0 jfet04 l=1.2 w=48.0
j3445 0 244 1028 0 jfet04 l=1.2 w=48.0
j3446 853 1028 0 0 jfet04 l=1.2 w=48.0
j3447 0 1028 853 0 jfet04 l=1.2 w=48.0
j3448 853 1027 0 0 jfet04 l=1.2 w=48.0
j3449 0 1027 853 0 jfet04 l=1.2 w=48.0
j3450 853 1026 0 0 jfet04 l=1.2 w=48.0
j3451 0 1026 853 0 jfet04 l=1.2 w=48.0
j3452 853 1025 0 0 jfet04 l=1.2 w=48.0
j3453 0 1025 853 0 jfet04 l=1.2 w=48.0
j3454 1029 253 0 0 jfet04 l=1.2 w=48.0
j3455 0 253 1029 0 jfet04 l=1.2 w=48.0
j3456 1030 931 0 0 jfet04 l=1.2 w=48.0
j3457 0 931 1030 0 jfet04 l=1.2 w=48.0
j3458 1031 244 0 0 jfet04 l=1.2 w=48.0
j3459 0 244 1031 0 jfet04 l=1.2 w=48.0
j3460 1032 243 0 0 jfet04 l=1.2 w=48.0
j3461 0 243 1032 0 jfet04 l=1.2 w=48.0
j3462 1033 1032 0 0 jfet04 l=1.2 w=48.0
j3463 0 1032 1033 0 jfet04 l=1.2 w=48.0
j3464 1033 1031 0 0 jfet04 l=1.2 w=48.0
j3465 0 1031 1033 0 jfet04 l=1.2 w=48.0

j3466 1033 1030 0 0 jfet04 l=1.2 w=48.0
j3467 0 1030 1033 0 jfet04 l=1.2 w=48.0
j3468 1033 1029 0 0 jfet04 l=1.2 w=48.0
j3469 0 1029 1033 0 jfet04 l=1.2 w=48.0
j3470 1034 1033 0 0 jfet04 l=1.2 w=48.0
j3471 0 1033 1034 0 jfet04 l=1.2 w=48.0
j3472 789 1035 789 248 dio16 l=1.2 w=20.0
j3473 1036 789 1036 248 dio16 l=1.2 w=10.0
j3474 248 248 1037 0 jfet20 l=3.2 w=3.2
j3475 1037 1038 1037 248 dio16 l=1.2 w=4.0
j3476 248 248 1039 0 jfet20 l=3.2 w=3.2
j3477 1039 1040 1039 248 dio16 l=1.2 w=4.0
j3478 1041 202 0 0 jfet04 l=1.2 w=48.0
j3479 0 244 1041 0 jfet04 l=1.2 w=48.0
j3480 1041 598 0 0 jfet04 l=1.2 w=48.0
j3481 1042 1041 1 0 jfet04 l=1.2 w=48.0
j3482 0 598 1042 0 jfet04 l=1.2 w=48.0
j3483 1042 244 0 0 jfet04 l=1.2 w=48.0
j3484 0 202 1042 0 jfet04 l=1.2 w=48.0
j3485 0 1042 1043 0 jfet04 l=1.2 w=48.0
j3486 441 1042 0 0 jfet04 l=1.2 w=48.0
j3487 1 1043 441 0 jfet04 l=1.2 w=48.0
j3488 0 441 1044 0 jfet04 l=1.2 w=48.0
j3489 1045 441 0 0 jfet04 l=1.2 w=48.0
j3490 1 1044 1045 0 jfet04 l=1.2 w=48.0
j3491 1046 1047 1 0 jfet04 l=1.2 w=48.0
j3492 0 599 1046 0 jfet04 l=1.2 w=48.0
j3493 1047 599 0 0 jfet04 l=1.2 w=48.0
j3494 0 600 1048 0 jfet04 l=1.2 w=48.0
j3495 1049 600 0 0 jfet04 l=1.2 w=48.0
j3496 1 1048 1049 0 jfet04 l=1.2 w=48.0
j3497 1050 1051 1 0 jfet04 l=1.2 w=48.0
j3498 0 439 1050 0 jfet04 l=1.2 w=48.0
j3499 1051 439 0 0 jfet04 l=1.2 w=48.0
j3500 0 1045 1052 0 jfet04 l=1.2 w=48.0
j3501 1052 1046 0 0 jfet04 l=1.2 w=48.0
j3502 0 1049 1052 0 jfet04 l=1.2 w=48.0
j3503 1052 1050 0 0 jfet04 l=1.2 w=48.0
j3504 1014 1052 1 0 jfet04 l=1.2 w=48.0
j3505 0 1050 1014 0 jfet04 l=1.2 w=48.0
j3506 1014 1049 0 0 jfet04 l=1.2 w=48.0
j3507 0 1046 1014 0 jfet04 l=1.2 w=48.0
j3508 1014 1045 0 0 jfet04 l=1.2 w=48.0
j3509 1040 1017 1 0 jfet04 l=1.2 w=20.0
j3510 1018 1053 1018 248 dio16 l=1.2 w=20.0
j3511 248 248 182 0 jfet16 l=1.2 w=12.0
j3512 1054 1019 1054 248 dio16 l=1.2 w=10.0
j3513 1 101 101 0 jfet16 l=1.2 w=6.0
j3514 1020 1020 1 0 jfet16 l=1.2 w=6.0
j3515 1 1021 1021 0 jfet16 l=1.2 w=6.0
j3516 1022 1022 1 0 jfet16 l=1.2 w=6.0

j3517 1 1023 1023 0 jfet16 l=1.2 w=6.0
j3518 1024 1024 1 0 jfet16 l=1.2 w=6.0
j3519 981 981 1 0 jfet16 l=1.2 w=6.0
j3520 1 1025 1025 0 jfet16 l=1.2 w=6.0
j3521 1026 1026 1 0 jfet16 l=1.2 w=6.0
j3522 1 1027 1027 0 jfet16 l=1.2 w=6.0
j3523 1028 1028 1 0 jfet16 l=1.2 w=6.0
j3524 1038 1034 1 0 jfet04 l=1.2 w=20.0
j3525 1035 1055 1035 248 dio16 l=1.2 w=20.0
j3526 248 248 789 0 jfet16 l=1.2 w=12.0
j3527 1056 1036 1056 248 dio16 l=1.2 w=10.0
j3528 853 853 1 0 jfet16 l=1.2 w=6.0
j3529 1 1029 1029 0 jfet16 l=1.2 w=6.0
j3530 1030 1030 1 0 jfet16 l=1.2 w=6.0
j3531 1 1031 1031 0 jfet16 l=1.2 w=6.0
j3532 1032 1032 1 0 jfet16 l=1.2 w=6.0
j3533 1033 1033 1 0 jfet16 l=1.2 w=6.0
j3534 1034 1034 1 0 jfet16 l=1.2 w=6.0
j3535 1057 1057 1 0 jfet16 l=1.2 w=3.2
j3536 0 1037 1057 0 jfet16 l=1.2 w=10.0
j3537 1055 1057 1 0 jfet16 l=1.2 w=20.0
j3538 1058 1056 1058 248 dio16 l=1.2 w=10.0
j3539 248 1058 248 248 dio16 l=1.2 w=10.0
j3540 1 1013 1013 0 jfet16 l=1.2 w=6.0
j3541 1015 1015 1 0 jfet16 l=1.2 w=6.0
j3542 1 1016 1016 0 jfet16 l=1.2 w=6.0
j3543 1017 1017 1 0 jfet16 l=1.2 w=6.0
j3544 1059 1059 1 0 jfet16 l=1.2 w=3.2
j3545 0 1039 1059 0 jfet16 l=1.2 w=10.0
j3546 1053 1059 1 0 jfet16 l=1.2 w=20.0
j3547 1060 1054 1060 248 dio16 l=1.2 w=10.0
j3548 248 1060 248 248 dio16 l=1.2 w=10.0
j3549 1 1043 1043 0 jfet16 l=1.2 w=3.2
j3550 1 1044 1044 0 jfet16 l=1.2 w=3.2
j3551 1047 1047 1 0 jfet16 l=1.2 w=3.2
j3552 1 1048 1048 0 jfet16 l=1.2 w=3.2
j3553 1051 1051 1 0 jfet16 l=1.2 w=3.2
j3554 1041 1041 1 0 jfet16 l=1.2 w=3.2
j3555 1052 1052 1 0 jfet16 l=1.2 w=3.2
j3556 1 1061 1061 0 jfet16 l=1.2 w=3.2
j3557 1062 1062 1 0 jfet16 l=1.2 w=3.2
j3558 1 1063 1063 0 jfet16 l=1.2 w=3.2
j3559 1064 1064 1 0 jfet16 l=1.2 w=3.2
j3560 1 1065 1065 0 jfet16 l=1.2 w=3.2
j3561 1066 1066 1 0 jfet16 l=1.2 w=3.2
j3562 0 1067 1061 0 jfet04 l=1.2 w=48.0
j3563 1068 1067 0 0 jfet04 l=1.2 w=48.0
j3564 1 1061 1068 0 jfet04 l=1.2 w=48.0
j3565 1068 1062 1 0 jfet04 l=1.2 w=48.0
j3566 0 1067 1068 0 jfet04 l=1.2 w=48.0
j3567 1062 1067 0 0 jfet04 l=1.2 w=48.0

j3568 0 1068 1063 0 jfet04 l=1.2 w=48.0
j3569 992 1068 0 0 jfet04 l=1.2 w=48.0
j3570 1 1063 992 0 jfet04 l=1.2 w=48.0
j3571 992 1064 1 0 jfet04 l=1.2 w=48.0
j3572 0 1068 992 0 jfet04 l=1.2 w=48.0
j3573 1064 1068 0 0 jfet04 l=1.2 w=48.0
j3574 0 1068 1065 0 jfet04 l=1.2 w=48.0
j3575 992 1068 0 0 jfet04 l=1.2 w=48.0
j3576 1 1065 992 0 jfet04 l=1.2 w=48.0
j3577 992 1066 1 0 jfet04 l=1.2 w=48.0
j3578 0 1068 992 0 jfet04 l=1.2 w=48.0
j3579 1066 1068 0 0 jfet04 l=1.2 w=48.0
j3580 0 1069 1067 0 jfet04 l=1.2 w=38.4
j3581 0 1067 1070 0 jfet04 l=1.2 w=19.2
j3582 0 1069 1071 0 jfet04 l=1.2 w=19.2
j3583 1067 1071 1 0 jfet16 l=1.6 w=4.0
j3584 1070 1071 1070 248 dio16 l=1.2 w=2.4
j3585 1071 1071 1 0 jfet16 l=2.4 w=4.0
j3586 1 1072 1073 0 jfet04 l=1.2 w=20.0
j3587 1 1074 0 0 jfet04 l=2.0 w=20.0
j3588 1 1075 1076 0 jfet04 l=1.2 w=20.0
j3589 1073 1073 1077 0 jfet16 l=1.6 w=3.6
j3590 0 1074 1 0 jfet04 l=2.0 w=20.0
j3591 1076 1076 1078 0 jfet16 l=1.6 w=4.0
j3592 1077 1077 1069 0 jfet16 l=1.6 w=3.6
j3593 1078 1078 1079 0 jfet16 l=1.6 w=4.0
j3594 1 1074 0 0 jfet04 l=2.0 w=20.0
j3595 1069 1079 0 0 jfet04 l=1.2 w=20.0
j3596 1079 1079 0 0 jfet04 l=1.2 w=20.0
j3597 0 1074 1080 0 jfet04 l=2.0 w=20.0
j3598 1080 1074 0 0 jfet04 l=2.0 w=20.0
j3599 0 1074 1080 0 jfet04 l=2.0 w=20.0
j3600 1080 1081 1075 0 jfet04 l=1.6 w=50.0
j3601 1080 1082 1072 0 jfet04 l=1.6 w=50.0
j3602 1072 1082 1080 0 jfet04 l=1.6 w=50.0
j3603 1080 1082 1072 0 jfet04 l=1.6 w=50.0
j3604 1075 1081 1080 0 jfet04 l=1.6 w=50.0
j3605 1080 1081 1075 0 jfet04 l=1.6 w=50.0
j3606 1072 1 1072 248 dio16 l=1.6 w=3.2
j3607 1075 1 1075 248 dio16 l=1.6 w=3.2
j3608 1 1082 1 248 dio16 l=1.2 w=47.2
j3609 1 1082 1 248 dio16 l=1.2 w=50.0
j3610 1 1082 1 248 dio16 l=1.2 w=50.0
j3611 1 1082 1 248 dio16 l=1.2 w=50.0
j3612 1 1082 1 248 dio16 l=1.2 w=50.0
j3613 1 1082 1 248 dio16 l=1.2 w=50.0
j3614 1082 0 1082 248 dio16 l=1.2 w=38.0
j3615 1082 0 1082 248 dio16 l=1.2 w=50.0
j3616 1082 0 1082 248 dio16 l=1.2 w=50.0
j3617 1082 0 1082 248 dio16 l=1.2 w=50.0
j3618 1082 0 1082 248 dio16 l=1.2 w=50.0

j3619 1082 0 1082 248 dio16 l=1.2 w=50.0
j3620 1 1083 1083 0 jfet16 l=1.2 w=3.2
j3621 1084 1084 1 0 jfet16 l=1.2 w=3.2
j3622 1 1085 1085 0 jfet16 l=1.2 w=3.2
j3623 1086 1086 1 0 jfet16 l=1.2 w=3.2
j3624 1 1087 1087 0 jfet16 l=1.2 w=3.2
j3625 1088 1088 1 0 jfet16 l=1.2 w=3.2
j3626 0 1089 1083 0 jfet04 l=1.2 w=48.0
j3627 1090 1089 0 0 jfet04 l=1.2 w=48.0
j3628 1 1083 1090 0 jfet04 l=1.2 w=48.0
j3629 1090 1084 1 0 jfet04 l=1.2 w=48.0
j3630 0 1089 1090 0 jfet04 l=1.2 w=48.0
j3631 1084 1089 0 0 jfet04 l=1.2 w=48.0
j3632 0 1090 1085 0 jfet04 l=1.2 w=48.0
j3633 993 1090 0 0 jfet04 l=1.2 w=48.0
j3634 1 1085 993 0 jfet04 l=1.2 w=48.0
j3635 993 1086 1 0 jfet04 l=1.2 w=48.0
j3636 0 1090 993 0 jfet04 l=1.2 w=48.0
j3637 1086 1090 0 0 jfet04 l=1.2 w=48.0
j3638 0 1090 1087 0 jfet04 l=1.2 w=48.0
j3639 993 1090 0 0 jfet04 l=1.2 w=48.0
j3640 1 1087 993 0 jfet04 l=1.2 w=48.0
j3641 993 1088 1 0 jfet04 l=1.2 w=48.0
j3642 0 1090 993 0 jfet04 l=1.2 w=48.0
j3643 1088 1090 0 0 jfet04 l=1.2 w=48.0
j3644 0 1091 1089 0 jfet04 l=1.2 w=38.4
j3645 0 1089 1092 0 jfet04 l=1.2 w=19.2
j3646 0 1091 1093 0 jfet04 l=1.2 w=19.2
j3647 1089 1093 1 0 jfet16 l=1.6 w=4.0
j3648 1092 1093 1092 248 dio16 l=1.2 w=2.4
j3649 1093 1093 1 0 jfet16 l=2.4 w=4.0
j3650 1 1094 1095 0 jfet04 l=1.2 w=20.0
j3651 1 1096 0 0 jfet04 l=2.0 w=20.0
j3652 1 1097 1098 0 jfet04 l=1.2 w=20.0
j3653 1095 1095 1099 0 jfet16 l=1.6 w=3.6
j3654 0 1096 1 0 jfet04 l=2.0 w=20.0
j3655 1098 1098 1100 0 jfet16 l=1.6 w=4.0
j3656 1099 1099 1091 0 jfet16 l=1.6 w=3.6
j3657 1100 1100 1101 0 jfet16 l=1.6 w=4.0
j3658 1 1096 0 0 jfet04 l=2.0 w=20.0
j3659 1091 1101 0 0 jfet04 l=1.2 w=20.0
j3660 1101 1101 0 0 jfet04 l=1.2 w=20.0
j3661 0 1096 1102 0 jfet04 l=2.0 w=20.0
j3662 1102 1096 0 0 jfet04 l=2.0 w=20.0
j3663 0 1096 1102 0 jfet04 l=2.0 w=20.0
j3664 1102 1081 1097 0 jfet04 l=1.6 w=50.0
j3665 1102 1103 1094 0 jfet04 l=1.6 w=50.0
j3666 1094 1103 1102 0 jfet04 l=1.6 w=50.0
j3667 1102 1103 1094 0 jfet04 l=1.6 w=50.0
j3668 1097 1081 1102 0 jfet04 l=1.6 w=50.0
j3669 1102 1081 1097 0 jfet04 l=1.6 w=50.0

j3670 1094 1 1094 248 dio16 l=1.6 w=3.2
j3671 1097 1 1097 248 dio16 l=1.6 w=3.2
j3672 1 1103 1 248 dio16 l=1.2 w=47.2
j3673 1 1103 1 248 dio16 l=1.2 w=50.0
j3674 1 1103 1 248 dio16 l=1.2 w=50.0
j3675 1 1103 1 248 dio16 l=1.2 w=50.0
j3676 1 1103 1 248 dio16 l=1.2 w=50.0
j3677 1 1103 1 248 dio16 l=1.2 w=50.0
j3678 1103 0 1103 248 dio16 l=1.2 w=38.0
j3679 1103 0 1103 248 dio16 l=1.2 w=50.0
j3680 1103 0 1103 248 dio16 l=1.2 w=50.0
j3681 1103 0 1103 248 dio16 l=1.2 w=50.0
j3682 1103 0 1103 248 dio16 l=1.2 w=50.0
j3683 1103 0 1103 248 dio16 l=1.2 w=50.0
j3684 1 1104 1104 0 jfet16 l=1.2 w=3.2
j3685 1105 1105 1 0 jfet16 l=1.2 w=3.2
j3686 1 1106 1106 0 jfet16 l=1.2 w=3.2
j3687 1107 1107 1 0 jfet16 l=1.2 w=3.2
j3688 1 1108 1108 0 jfet16 l=1.2 w=3.2
j3689 1109 1109 1 0 jfet16 l=1.2 w=3.2
j3690 0 1110 1104 0 jfet04 l=1.2 w=48.0
j3691 1111 1110 0 0 jfet04 l=1.2 w=48.0
j3692 1 1104 1111 0 jfet04 l=1.2 w=48.0
j3693 1111 1105 1 0 jfet04 l=1.2 w=48.0
j3694 0 1110 1111 0 jfet04 l=1.2 w=48.0
j3695 1105 1110 0 0 jfet04 l=1.2 w=48.0
j3696 0 1111 1106 0 jfet04 l=1.2 w=48.0
j3697 466 1111 0 0 jfet04 l=1.2 w=48.0
j3698 1 1106 466 0 jfet04 l=1.2 w=48.0
j3699 466 1107 1 0 jfet04 l=1.2 w=48.0
j3700 0 1111 466 0 jfet04 l=1.2 w=48.0
j3701 1107 1111 0 0 jfet04 l=1.2 w=48.0
j3702 0 1111 1108 0 jfet04 l=1.2 w=48.0
j3703 466 1111 0 0 jfet04 l=1.2 w=48.0
j3704 1 1108 466 0 jfet04 l=1.2 w=48.0
j3705 466 1109 1 0 jfet04 l=1.2 w=48.0
j3706 0 1111 466 0 jfet04 l=1.2 w=48.0
j3707 1109 1111 0 0 jfet04 l=1.2 w=48.0
j3708 0 1112 1110 0 jfet04 l=1.2 w=38.4
j3709 0 1110 1113 0 jfet04 l=1.2 w=19.2
j3710 0 1112 1114 0 jfet04 l=1.2 w=19.2
j3711 1110 1114 1 0 jfet16 l=1.6 w=4.0
j3712 1113 1114 1113 248 dio16 l=1.2 w=2.4
j3713 1114 1114 1 0 jfet16 l=2.4 w=4.0
j3714 1 1115 1116 0 jfet04 l=1.2 w=20.0
j3715 1 1117 0 0 jfet04 l=2.0 w=20.0
j3716 1 1118 1119 0 jfet04 l=1.2 w=20.0
j3717 1116 1116 1120 0 jfet16 l=1.6 w=3.6
j3718 0 1117 1 0 jfet04 l=2.0 w=20.0
j3719 1119 1119 1121 0 jfet16 l=1.6 w=4.0
j3720 1120 1120 1112 0 jfet16 l=1.6 w=3.6

j3721 1121 1121 1122 0 jfet16 l=1.6 w=4.0
j3722 1 1117 0 0 jfet04 l=2.0 w=20.0
j3723 1112 1122 0 0 jfet04 l=1.2 w=20.0
j3724 1122 1122 0 0 jfet04 l=1.2 w=20.0
j3725 0 1117 1123 0 jfet04 l=2.0 w=20.0
j3726 1123 1117 0 0 jfet04 l=2.0 w=20.0
j3727 0 1117 1123 0 jfet04 l=2.0 w=20.0
j3728 1123 1081 1118 0 jfet04 l=1.6 w=50.0
j3729 1123 1124 1115 0 jfet04 l=1.6 w=50.0
j3730 1115 1124 1123 0 jfet04 l=1.6 w=50.0
j3731 1123 1124 1115 0 jfet04 l=1.6 w=50.0
j3732 1118 1081 1123 0 jfet04 l=1.6 w=50.0
j3733 1123 1081 1118 0 jfet04 l=1.6 w=50.0
j3734 1115 1 1115 248 dio16 l=1.6 w=3.2
j3735 1118 1 1118 248 dio16 l=1.6 w=3.2
j3736 1 1124 1 248 dio16 l=1.2 w=47.2
j3737 1 1124 1 248 dio16 l=1.2 w=50.0
j3738 1 1124 1 248 dio16 l=1.2 w=50.0
j3739 1 1124 1 248 dio16 l=1.2 w=50.0
j3740 1 1124 1 248 dio16 l=1.2 w=50.0
j3741 1 1124 1 248 dio16 l=1.2 w=50.0
j3742 1124 0 1124 248 dio16 l=1.2 w=38.0
j3743 1124 0 1124 248 dio16 l=1.2 w=50.0
j3744 1124 0 1124 248 dio16 l=1.2 w=50.0
j3745 1124 0 1124 248 dio16 l=1.2 w=50.0
j3746 1124 0 1124 248 dio16 l=1.2 w=50.0
j3747 1124 0 1124 248 dio16 l=1.2 w=50.0
j3748 1 1125 1125 0 jfet16 l=1.2 w=3.2
j3749 1126 1126 1 0 jfet16 l=1.2 w=3.2
j3750 1 1127 1127 0 jfet16 l=1.2 w=3.2
j3751 1128 1128 1 0 jfet16 l=1.2 w=3.2
j3752 1 1129 1129 0 jfet16 l=1.2 w=3.2
j3753 1130 1130 1 0 jfet16 l=1.2 w=3.2
j3754 0 1131 1125 0 jfet04 l=1.2 w=48.0
j3755 1132 1131 0 0 jfet04 l=1.2 w=48.0
j3756 1 1125 1132 0 jfet04 l=1.2 w=48.0
j3757 1132 1126 1 0 jfet04 l=1.2 w=48.0
j3758 0 1131 1132 0 jfet04 l=1.2 w=48.0
j3759 1126 1131 0 0 jfet04 l=1.2 w=48.0
j3760 0 1132 1127 0 jfet04 l=1.2 w=48.0
j3761 901 1132 0 0 jfet04 l=1.2 w=48.0
j3762 1 1127 901 0 jfet04 l=1.2 w=48.0
j3763 901 1128 1 0 jfet04 l=1.2 w=48.0
j3764 0 1132 901 0 jfet04 l=1.2 w=48.0
j3765 1128 1132 0 0 jfet04 l=1.2 w=48.0
j3766 0 1132 1129 0 jfet04 l=1.2 w=48.0
j3767 901 1132 0 0 jfet04 l=1.2 w=48.0
j3768 1 1129 901 0 jfet04 l=1.2 w=48.0
j3769 901 1130 1 0 jfet04 l=1.2 w=48.0
j3770 0 1132 901 0 jfet04 l=1.2 w=48.0
j3771 1130 1132 0 0 jfet04 l=1.2 w=48.0

j3772 0 1133 1131 0 jfet04 l=1.2 w=38.4
j3773 0 1131 1134 0 jfet04 l=1.2 w=19.2
j3774 0 1133 1135 0 jfet04 l=1.2 w=19.2
j3775 1131 1135 1 0 jfet16 l=1.6 w=4.0
j3776 1134 1135 1134 248 diol6 l=1.2 w=2.4
j3777 1135 1135 1 0 jfet16 l=2.4 w=4.0
j3778 1 1136 1137 0 jfet04 l=1.2 w=20.0
j3779 1 1138 0 0 jfet04 l=2.0 w=20.0
j3780 1 1139 1140 0 jfet04 l=1.2 w=20.0
j3781 1137 1137 1141 0 jfet16 l=1.6 w=3.6
j3782 0 1138 1 0 jfet04 l=2.0 w=20.0
j3783 1140 1140 1142 0 jfet16 l=1.6 w=4.0
j3784 1141 1141 1133 0 jfet16 l=1.6 w=3.6
j3785 1142 1142 1143 0 jfet16 l=1.6 w=4.0
j3786 1 1138 0 0 jfet04 l=2.0 w=20.0
j3787 1133 1143 0 0 jfet04 l=1.2 w=20.0
j3788 1143 1143 0 0 jfet04 l=1.2 w=20.0
j3789 0 1138 1144 0 jfet04 l=2.0 w=20.0
j3790 1144 1138 0 0 jfet04 l=2.0 w=20.0
j3791 0 1138 1144 0 jfet04 l=2.0 w=20.0
j3792 1144 1081 1139 0 jfet04 l=1.6 w=50.0
j3793 1144 1145 1136 0 jfet04 l=1.6 w=50.0
j3794 1136 1145 1144 0 jfet04 l=1.6 w=50.0
j3795 1144 1145 1136 0 jfet04 l=1.6 w=50.0
j3796 1139 1081 1144 0 jfet04 l=1.6 w=50.0
j3797 1144 1081 1139 0 jfet04 l=1.6 w=50.0
j3798 1136 1 1136 248 diol6 l=1.6 w=3.2
j3799 1139 1 1139 248 diol6 l=1.6 w=3.2
j3800 1 1145 1 248 diol6 l=1.2 w=47.2
j3801 1 1145 1 248 diol6 l=1.2 w=50.0
j3802 1 1145 1 248 diol6 l=1.2 w=50.0
j3803 1 1145 1 248 diol6 l=1.2 w=50.0
j3804 1 1145 1 248 diol6 l=1.2 w=50.0
j3805 1 1145 1 248 diol6 l=1.2 w=50.0
j3806 1145 0 1145 248 diol6 l=1.2 w=38.0
j3807 1145 0 1145 248 diol6 l=1.2 w=50.0
j3808 1145 0 1145 248 diol6 l=1.2 w=50.0
j3809 1145 0 1145 248 diol6 l=1.2 w=50.0
j3810 1145 0 1145 248 diol6 l=1.2 w=50.0
j3811 1145 0 1145 248 diol6 l=1.2 w=50.0
j3812 1 1146 1146 0 jfet16 l=1.2 w=3.2
j3813 1147 1147 1 0 jfet16 l=1.2 w=3.2
j3814 1 1148 1148 0 jfet16 l=1.2 w=3.2
j3815 1149 1149 1 0 jfet16 l=1.2 w=3.2
j3816 1 1150 1150 0 jfet16 l=1.2 w=3.2
j3817 1151 1151 1 0 jfet16 l=1.2 w=3.2
j3818 0 1152 1146 0 jfet04 l=1.2 w=48.0
j3819 1153 1152 0 0 jfet04 l=1.2 w=48.0
j3820 1 1146 1153 0 jfet04 l=1.2 w=48.0
j3821 1153 1147 1 0 jfet04 l=1.2 w=48.0
j3822 0 1152 1153 0 jfet04 l=1.2 w=48.0

j3823 1147 1152 0 0 jfet04 l=1.2 w=48.0
j3824 0 1153 1148 0 jfet04 l=1.2 w=48.0
j3825 227 1153 0 0 jfet04 l=1.2 w=48.0
j3826 1 1148 227 0 jfet04 l=1.2 w=48.0
j3827 227 1149 1 0 jfet04 l=1.2 w=48.0
j3828 0 1153 227 0 jfet04 l=1.2 w=48.0
j3829 1149 1153 0 0 jfet04 l=1.2 w=48.0
j3830 0 1153 1150 0 jfet04 l=1.2 w=48.0
j3831 227 1153 0 0 jfet04 l=1.2 w=48.0
j3832 1 1150 227 0 jfet04 l=1.2 w=48.0
j3833 227 1151 1 0 jfet04 l=1.2 w=48.0
j3834 0 1153 227 0 jfet04 l=1.2 w=48.0
j3835 1151 1153 0 0 jfet04 l=1.2 w=48.0
j3836 0 1154 1152 0 jfet04 l=1.2 w=38.4
j3837 0 1152 1155 0 jfet04 l=1.2 w=19.2
j3838 0 1154 1156 0 jfet04 l=1.2 w=19.2
j3839 1152 1156 1 0 jfet16 l=1.6 w=4.0
j3840 1155 1156 1155 248 dio16 l=1.2 w=2.4
j3841 1156 1156 1 0 jfet16 l=2.4 w=4.0
j3842 1 1157 1158 0 jfet04 l=1.2 w=20.0
j3843 1 1159 0 0 jfet04 l=2.0 w=20.0
j3844 1 1160 1161 0 jfet04 l=1.2 w=20.0
j3845 1158 1158 1162 0 jfet16 l=1.6 w=3.6
j3846 0 1159 1 0 jfet04 l=2.0 w=20.0
j3847 1161 1161 1163 0 jfet16 l=1.6 w=4.0
j3848 1162 1162 1154 0 jfet16 l=1.6 w=3.6
j3849 1163 1163 1164 0 jfet16 l=1.6 w=4.0
j3850 1 1159 0 0 jfet04 l=2.0 w=20.0
j3851 1154 1164 0 0 jfet04 l=1.2 w=20.0
j3852 1164 1164 0 0 jfet04 l=1.2 w=20.0
j3853 0 1159 1165 0 jfet04 l=2.0 w=20.0
j3854 1165 1159 0 0 jfet04 l=2.0 w=20.0
j3855 0 1159 1165 0 jfet04 l=2.0 w=20.0
j3856 1165 1081 1160 0 jfet04 l=1.6 w=50.0
j3857 1165 1166 1157 0 jfet04 l=1.6 w=50.0
j3858 1157 1166 1165 0 jfet04 l=1.6 w=50.0
j3859 1165 1166 1157 0 jfet04 l=1.6 w=50.0
j3860 1160 1081 1165 0 jfet04 l=1.6 w=50.0
j3861 1165 1081 1160 0 jfet04 l=1.6 w=50.0
j3862 1157 1 1157 248 dio16 l=1.6 w=3.2
j3863 1160 1 1160 248 dio16 l=1.6 w=3.2
j3864 1 1166 1 248 dio16 l=1.2 w=47.2
j3865 1 1166 1 248 dio16 l=1.2 w=50.0
j3866 1 1166 1 248 dio16 l=1.2 w=50.0
j3867 1 1166 1 248 dio16 l=1.2 w=50.0
j3868 1 1166 1 248 dio16 l=1.2 w=50.0
j3869 1 1166 1 248 dio16 l=1.2 w=50.0
j3870 1166 0 1166 248 dio16 l=1.2 w=38.0
j3871 1166 0 1166 248 dio16 l=1.2 w=50.0
j3872 1166 0 1166 248 dio16 l=1.2 w=50.0
j3873 1166 0 1166 248 dio16 l=1.2 w=50.0

j3874 1166 0 1166 248 dio16 l=1.2 w=50.0
j3875 1166 0 1166 248 dio16 l=1.2 w=50.0
j3876 1 1167 1167 0 jfet16 l=1.2 w=3.2
j3877 1168 1168 1 0 jfet16 l=1.2 w=3.2
j3878 1 1169 1169 0 jfet16 l=1.2 w=3.2
j3879 1170 1170 1 0 jfet16 l=1.2 w=3.2
j3880 1 1171 1171 0 jfet16 l=1.2 w=3.2
j3881 1172 1172 1 0 jfet16 l=1.2 w=3.2
j3882 0 1173 1167 0 jfet04 l=1.2 w=48.0
j3883 1174 1173 0 0 jfet04 l=1.2 w=48.0
j3884 1 1167 1174 0 jfet04 l=1.2 w=48.0
j3885 1174 1168 1 0 jfet04 l=1.2 w=48.0
j3886 0 1173 1174 0 jfet04 l=1.2 w=48.0
j3887 1168 1173 0 0 jfet04 l=1.2 w=48.0
j3888 0 1174 1169 0 jfet04 l=1.2 w=48.0
j3889 253 1174 0 0 jfet04 l=1.2 w=48.0
j3890 1 1169 253 0 jfet04 l=1.2 w=48.0
j3891 253 1170 1 0 jfet04 l=1.2 w=48.0
j3892 0 1174 253 0 jfet04 l=1.2 w=48.0
j3893 1170 1174 0 0 jfet04 l=1.2 w=48.0
j3894 0 1174 1171 0 jfet04 l=1.2 w=48.0
j3895 253 1174 0 0 jfet04 l=1.2 w=48.0
j3896 1 1171 253 0 jfet04 l=1.2 w=48.0
j3897 253 1172 1 0 jfet04 l=1.2 w=48.0
j3898 0 1174 253 0 jfet04 l=1.2 w=48.0
j3899 1172 1174 0 0 jfet04 l=1.2 w=48.0
j3900 0 1175 1173 0 jfet04 l=1.2 w=38.4
j3901 0 1173 1176 0 jfet04 l=1.2 w=19.2
j3902 0 1175 1177 0 jfet04 l=1.2 w=19.2
j3903 1173 1177 1 0 jfet16 l=1.6 w=4.0
j3904 1176 1177 1176 248 dio16 l=1.2 w=2.4
j3905 1177 1177 1 0 jfet16 l=2.4 w=4.0
j3906 1 1178 1179 0 jfet04 l=1.2 w=20.0
j3907 1 1180 0 0 jfet04 l=2.0 w=20.0
j3908 1 1181 1182 0 jfet04 l=1.2 w=20.0
j3909 1179 1179 1183 0 jfet16 l=1.6 w=3.6
j3910 0 1180 1 0 jfet04 l=2.0 w=20.0
j3911 1182 1182 1184 0 jfet16 l=1.6 w=4.0
j3912 1183 1183 1175 0 jfet16 l=1.6 w=3.6
j3913 1184 1184 1185 0 jfet16 l=1.6 w=4.0
j3914 1 1180 0 0 jfet04 l=2.0 w=20.0
j3915 1175 1185 0 0 jfet04 l=1.2 w=20.0
j3916 1185 1185 0 0 jfet04 l=1.2 w=20.0
j3917 0 1180 1186 0 jfet04 l=2.0 w=20.0
j3918 1186 1180 0 0 jfet04 l=2.0 w=20.0
j3919 0 1180 1186 0 jfet04 l=2.0 w=20.0
j3920 1186 1081 1181 0 jfet04 l=1.6 w=50.0
j3921 1186 1187 1178 0 jfet04 l=1.6 w=50.0
j3922 1178 1187 1186 0 jfet04 l=1.6 w=50.0
j3923 1186 1187 1178 0 jfet04 l=1.6 w=50.0
j3924 1181 1081 1186 0 jfet04 l=1.6 w=50.0

j3925 1186 1081 1181 0 jfet04 l=1.6 w=50.0
j3926 1178 1 1178 248 dio16 l=1.6 w=3.2
j3927 1181 1 1181 248 dio16 l=1.6 w=3.2
j3928 1 1187 1 248 dio16 l=1.2 w=47.2
j3929 1 1187 1 248 dio16 l=1.2 w=50.0
j3930 1 1187 1 248 dio16 l=1.2 w=50.0
j3931 1 1187 1 248 dio16 l=1.2 w=50.0
j3932 1 1187 1 248 dio16 l=1.2 w=50.0
j3933 1 1187 1 248 dio16 l=1.2 w=50.0
j3934 1187 0 1187 248 dio16 l=1.2 w=38.0
j3935 1187 0 1187 248 dio16 l=1.2 w=50.0
j3936 1187 0 1187 248 dio16 l=1.2 w=50.0
j3937 1187 0 1187 248 dio16 l=1.2 w=50.0
j3938 1187 0 1187 248 dio16 l=1.2 w=50.0
j3939 1187 0 1187 248 dio16 l=1.2 w=50.0
j3940 1 1188 1188 0 jfet16 l=1.2 w=3.2
j3941 1189 1189 1 0 jfet16 l=1.2 w=3.2
j3942 1 1190 1190 0 jfet16 l=1.2 w=3.2
j3943 1191 1191 1 0 jfet16 l=1.2 w=3.2
j3944 1 1192 1192 0 jfet16 l=1.2 w=3.2
j3945 1193 1193 1 0 jfet16 l=1.2 w=3.2
j3946 0 1194 1188 0 jfet04 l=1.2 w=48.0
j3947 1195 1194 0 0 jfet04 l=1.2 w=48.0
j3948 1 1188 1195 0 jfet04 l=1.2 w=48.0
j3949 1195 1189 1 0 jfet04 l=1.2 w=48.0
j3950 0 1194 1195 0 jfet04 l=1.2 w=48.0
j3951 1189 1194 0 0 jfet04 l=1.2 w=48.0
j3952 0 1195 1190 0 jfet04 l=1.2 w=48.0
j3953 965 1195 0 0 jfet04 l=1.2 w=48.0
j3954 1 1190 965 0 jfet04 l=1.2 w=48.0
j3955 965 1191 1 0 jfet04 l=1.2 w=48.0
j3956 0 1195 965 0 jfet04 l=1.2 w=48.0
j3957 1191 1195 0 0 jfet04 l=1.2 w=48.0
j3958 0 1195 1192 0 jfet04 l=1.2 w=48.0
j3959 965 1195 0 0 jfet04 l=1.2 w=48.0
j3960 1 1192 965 0 jfet04 l=1.2 w=48.0
j3961 965 1193 1 0 jfet04 l=1.2 w=48.0
j3962 0 1195 965 0 jfet04 l=1.2 w=48.0
j3963 1193 1195 0 0 jfet04 l=1.2 w=48.0
j3964 0 1196 1194 0 jfet04 l=1.2 w=38.4
j3965 0 1194 1197 0 jfet04 l=1.2 w=19.2
j3966 0 1196 1198 0 jfet04 l=1.2 w=19.2
j3967 1194 1198 1 0 jfet16 l=1.6 w=4.0
j3968 1197 1198 1197 248 dio16 l=1.2 w=2.4
j3969 1198 1198 1 0 jfet16 l=2.4 w=4.0
j3970 1 1199 1200 0 jfet04 l=1.2 w=20.0
j3971 1 1201 0 0 jfet04 l=2.0 w=20.0
j3972 1 1202 1203 0 jfet04 l=1.2 w=20.0
j3973 1200 1200 1204 0 jfet16 l=1.6 w=3.6
j3974 0 1201 1 0 jfet04 l=2.0 w=20.0
j3975 1203 1203 1205 0 jfet16 l=1.6 w=4.0

j3976 1204 1204 1196 0 jfet16 l=1.6 w=3.6
j3977 1205 1205 1206 0 jfet16 l=1.6 w=4.0
j3978 1 1201 0 0 jfet04 l=2.0 w=20.0
j3979 1196 1206 0 0 jfet04 l=1.2 w=20.0
j3980 1206 1206 0 0 jfet04 l=1.2 w=20.0
j3981 0 1201 1207 0 jfet04 l=2.0 w=20.0
j3982 1207 1201 0 0 jfet04 l=2.0 w=20.0
j3983 0 1201 1207 0 jfet04 l=2.0 w=20.0
j3984 1207 1081 1202 0 jfet04 l=1.6 w=50.0
j3985 1207 1208 1199 0 jfet04 l=1.6 w=50.0
j3986 1199 1208 1207 0 jfet04 l=1.6 w=50.0
j3987 1207 1208 1199 0 jfet04 l=1.6 w=50.0
j3988 1202 1081 1207 0 jfet04 l=1.6 w=50.0
j3989 1207 1081 1202 0 jfet04 l=1.6 w=50.0
j3990 1199 1 1199 248 dio16 l=1.6 w=3.2
j3991 1202 1 1202 248 dio16 l=1.6 w=3.2
j3992 1 1208 1 248 dio16 l=1.2 w=47.2
j3993 1 1208 1 248 dio16 l=1.2 w=50.0
j3994 1 1208 1 248 dio16 l=1.2 w=50.0
j3995 1 1208 1 248 dio16 l=1.2 w=50.0
j3996 1 1208 1 248 dio16 l=1.2 w=50.0
j3997 1 1208 1 248 dio16 l=1.2 w=50.0
j3998 1208 0 1208 248 dio16 l=1.2 w=38.0
j3999 1208 0 1208 248 dio16 l=1.2 w=50.0
j4000 1208 0 1208 248 dio16 l=1.2 w=50.0
j4001 1208 0 1208 248 dio16 l=1.2 w=50.0
j4002 1208 0 1208 248 dio16 l=1.2 w=50.0
j4003 1208 0 1208 248 dio16 l=1.2 w=50.0
j4004 1 1209 1209 0 jfet16 l=1.2 w=3.2
j4005 1210 1210 1 0 jfet16 l=1.2 w=3.2
j4006 1 1211 1211 0 jfet16 l=1.2 w=3.2
j4007 1212 1212 1 0 jfet16 l=1.2 w=3.2
j4008 1 1213 1213 0 jfet16 l=1.2 w=3.2
j4009 1214 1214 1 0 jfet16 l=1.2 w=3.2
j4010 0 1215 1209 0 jfet04 l=1.2 w=48.0
j4011 1216 1215 0 0 jfet04 l=1.2 w=48.0
j4012 1 1209 1216 0 jfet04 l=1.2 w=48.0
j4013 1216 1210 1 0 jfet04 l=1.2 w=48.0
j4014 0 1215 1216 0 jfet04 l=1.2 w=48.0
j4015 1210 1215 0 0 jfet04 l=1.2 w=48.0
j4016 0 1216 1211 0 jfet04 l=1.2 w=48.0
j4017 604 1216 0 0 jfet04 l=1.2 w=48.0
j4018 1 1211 604 0 jfet04 l=1.2 w=48.0
j4019 604 1212 1 0 jfet04 l=1.2 w=48.0
j4020 0 1216 604 0 jfet04 l=1.2 w=48.0
j4021 1212 1216 0 0 jfet04 l=1.2 w=48.0
j4022 0 1216 1213 0 jfet04 l=1.2 w=48.0
j4023 604 1216 0 0 jfet04 l=1.2 w=48.0
j4024 1 1213 604 0 jfet04 l=1.2 w=48.0
j4025 604 1214 1 0 jfet04 l=1.2 w=48.0
j4026 0 1216 604 0 jfet04 l=1.2 w=48.0

j4027 1214 1216 0 0 jfet04 l=1.2 w=48.0
j4028 0 1217 1215 0 jfet04 l=1.2 w=38.4
j4029 0 1215 1218 0 jfet04 l=1.2 w=19.2
j4030 0 1217 1219 0 jfet04 l=1.2 w=19.2
j4031 1215 1219 1 0 jfet16 l=1.6 w=4.0
j4032 1218 1219 1218 248 dio16 l=1.2 w=2.4
j4033 1219 1219 1 0 jfet16 l=2.4 w=4.0
j4034 1 1220 1221 0 jfet04 l=1.2 w=20.0
j4035 1 1222 0 0 jfet04 l=2.0 w=20.0
j4036 1 1223 1224 0 jfet04 l=1.2 w=20.0
j4037 1221 1221 1225 0 jfet16 l=1.6 w=3.6
j4038 0 1222 1 0 jfet04 l=2.0 w=20.0
j4039 1224 1224 1226 0 jfet16 l=1.6 w=4.0
j4040 1225 1225 1217 0 jfet16 l=1.6 w=3.6
j4041 1226 1226 1227 0 jfet16 l=1.6 w=4.0
j4042 1 1222 0 0 jfet04 l=2.0 w=20.0
j4043 1217 1227 0 0 jfet04 l=1.2 w=20.0
j4044 1227 1227 0 0 jfet04 l=1.2 w=20.0
j4045 0 1222 1228 0 jfet04 l=2.0 w=20.0
j4046 1228 1222 0 0 jfet04 l=2.0 w=20.0
j4047 0 1222 1228 0 jfet04 l=2.0 w=20.0
j4048 1228 1081 1223 0 jfet04 l=1.6 w=50.0
j4049 1228 1229 1220 0 jfet04 l=1.6 w=50.0
j4050 1220 1229 1228 0 jfet04 l=1.6 w=50.0
j4051 1228 1229 1220 0 jfet04 l=1.6 w=50.0
j4052 1223 1081 1228 0 jfet04 l=1.6 w=50.0
j4053 1228 1081 1223 0 jfet04 l=1.6 w=50.0
j4054 1220 1 1220 248 dio16 l=1.6 w=3.2
j4055 1223 1 1223 248 dio16 l=1.6 w=3.2
j4056 1 1229 1 248 dio16 l=1.2 w=47.2
j4057 1 1229 1 248 dio16 l=1.2 w=50.0
j4058 1 1229 1 248 dio16 l=1.2 w=50.0
j4059 1 1229 1 248 dio16 l=1.2 w=50.0
j4060 1 1229 1 248 dio16 l=1.2 w=50.0
j4061 1 1229 1 248 dio16 l=1.2 w=50.0
j4062 1229 0 1229 248 dio16 l=1.2 w=38.0
j4063 1229 0 1229 248 dio16 l=1.2 w=50.0
j4064 1229 0 1229 248 dio16 l=1.2 w=50.0
j4065 1229 0 1229 248 dio16 l=1.2 w=50.0
j4066 1229 0 1229 248 dio16 l=1.2 w=50.0
j4067 1229 0 1229 248 dio16 l=1.2 w=50.0
j4068 1 1230 1230 0 jfet16 l=1.2 w=3.2
j4069 1231 1231 1 0 jfet16 l=1.2 w=3.2
j4070 1 1232 1232 0 jfet16 l=1.2 w=3.2
j4071 1233 1233 1 0 jfet16 l=1.2 w=3.2
j4072 1 1234 1234 0 jfet16 l=1.2 w=3.2
j4073 1235 1235 1 0 jfet16 l=1.2 w=3.2
j4074 0 1236 1230 0 jfet04 l=1.2 w=48.0
j4075 1237 1236 0 0 jfet04 l=1.2 w=48.0
j4076 1 1230 1237 0 jfet04 l=1.2 w=48.0
j4077 1237 1231 1 0 jfet04 l=1.2 w=48.0

j4078 0 1236 1237 0 jfet04 l=1.2 w=48.0
j4079 1231 1236 0 0 jfet04 l=1.2 w=48.0
j4080 0 1237 1232 0 jfet04 l=1.2 w=48.0
j4081 372 1237 0 0 jfet04 l=1.2 w=48.0
j4082 1 1232 372 0 jfet04 l=1.2 w=48.0
j4083 372 1233 1 0 jfet04 l=1.2 w=48.0
j4084 0 1237 372 0 jfet04 l=1.2 w=48.0
j4085 1233 1237 0 0 jfet04 l=1.2 w=48.0
j4086 0 1237 1234 0 jfet04 l=1.2 w=48.0
j4087 372 1237 0 0 jfet04 l=1.2 w=48.0
j4088 1 1234 372 0 jfet04 l=1.2 w=48.0
j4089 372 1235 1 0 jfet04 l=1.2 w=48.0
j4090 0 1237 372 0 jfet04 l=1.2 w=48.0
j4091 1235 1237 0 0 jfet04 l=1.2 w=48.0
j4092 0 1238 1236 0 jfet04 l=1.2 w=38.4
j4093 0 1236 1239 0 jfet04 l=1.2 w=19.2
j4094 0 1238 1240 0 jfet04 l=1.2 w=19.2
j4095 1236 1240 1 0 jfet16 l=1.6 w=4.0
j4096 1239 1240 1239 248 dio16 l=1.2 w=2.4
j4097 1240 1240 1 0 jfet16 l=2.4 w=4.0
j4098 1 1241 1242 0 jfet04 l=1.2 w=20.0
j4099 1 1243 0 0 jfet04 l=2.0 w=20.0
j4100 1 1244 1245 0 jfet04 l=1.2 w=20.0
j4101 1242 1242 1246 0 jfet16 l=1.6 w=3.6
j4102 0 1243 1 0 jfet04 l=2.0 w=20.0
j4103 1245 1245 1247 0 jfet16 l=1.6 w=4.0
j4104 1246 1246 1238 0 jfet16 l=1.6 w=3.6
j4105 1247 1247 1248 0 jfet16 l=1.6 w=4.0
j4106 1 1243 0 0 jfet04 l=2.0 w=20.0
j4107 1238 1248 0 0 jfet04 l=1.2 w=20.0
j4108 1248 1248 0 0 jfet04 l=1.2 w=20.0
j4109 0 1243 1249 0 jfet04 l=2.0 w=20.0
j4110 1249 1243 0 0 jfet04 l=2.0 w=20.0
j4111 0 1243 1249 0 jfet04 l=2.0 w=20.0
j4112 1249 1081 1244 0 jfet04 l=1.6 w=50.0
j4113 1249 1250 1241 0 jfet04 l=1.6 w=50.0
j4114 1241 1250 1249 0 jfet04 l=1.6 w=50.0
j4115 1249 1250 1241 0 jfet04 l=1.6 w=50.0
j4116 1244 1081 1249 0 jfet04 l=1.6 w=50.0
j4117 1249 1081 1244 0 jfet04 l=1.6 w=50.0
j4118 1241 1 1241 248 dio16 l=1.6 w=3.2
j4119 1244 1 1244 248 dio16 l=1.6 w=3.2
j4120 1 1250 1 248 dio16 l=1.2 w=47.2
j4121 1 1250 1 248 dio16 l=1.2 w=50.0
j4122 1 1250 1 248 dio16 l=1.2 w=50.0
j4123 1 1250 1 248 dio16 l=1.2 w=50.0
j4124 1 1250 1 248 dio16 l=1.2 w=50.0
j4125 1 1250 1 248 dio16 l=1.2 w=50.0
j4126 1250 0 1250 248 dio16 l=1.2 w=38.0
j4127 1250 0 1250 248 dio16 l=1.2 w=50.0
j4128 1250 0 1250 248 dio16 l=1.2 w=50.0

j4129 1250 0 1250 248 dio16 l=1.2 w=50.0
j4130 1250 0 1250 248 dio16 l=1.2 w=50.0
j4131 1250 0 1250 248 dio16 l=1.2 w=50.0
j4132 1 1251 1251 0 jfet16 l=1.2 w=3.2
j4133 1252 1252 1 0 jfet16 l=1.2 w=3.2
j4134 1 1253 1253 0 jfet15 l=1.2 w=3.2
j4135 1254 1254 1 0 jfet16 l=1.2 w=3.2
j4136 1 1255 1255 0 jfet16 l=1.2 w=3.2
j4137 1256 1256 1 0 jfet16 l=1.2 w=3.2
j4138 0 1257 1251 0 jfet04 l=1.2 w=48.0
j4139 1258 1257 0 0 jfet04 l=1.2 w=48.0
j4140 1 1251 1258 0 jfet04 l=1.2 w=48.0
j4141 1258 1252 1 0 jfet04 l=1.2 w=48.0
j4142 0 1257 1258 0 jfet04 l=1.2 w=48.0
j4143 1252 1257 0 0 jfet04 l=1.2 w=48.0
j4144 0 1258 1253 0 jfet04 l=1.2 w=48.0
j4145 225 1258 0 0 jfet04 l=1.2 w=48.0
j4146 1 1253 225 0 jfet04 l=1.2 w=48.0
j4147 225 1254 1 0 jfet04 l=1.2 w=48.0
j4148 0 1258 225 0 jfet04 l=1.2 w=48.0
j4149 1254 1258 0 0 jfet04 l=1.2 w=48.0
j4150 0 1258 1255 0 jfet04 l=1.2 w=48.0
j4151 225 1258 0 0 jfet04 l=1.2 w=48.0
j4152 1 1255 225 0 jfet04 l=1.2 w=48.0
j4153 225 1256 1 0 jfet04 l=1.2 w=48.0
j4154 0 1258 225 0 jfet04 l=1.2 w=48.0
j4155 1256 1258 0 0 jfet04 l=1.2 w=48.0
j4156 0 1259 1257 0 jfet04 l=1.2 w=38.4
j4157 0 1257 1260 0 jfet04 l=1.2 w=19.2
j4158 0 1259 1261 0 jfet04 l=1.2 w=19.2
j4159 1257 1261 1 0 jfet16 l=1.6 w=4.0
j4160 1260 1261 1260 248 dio16 l=1.2 w=2.4
j4161 1261 1261 1 0 jfet16 l=2.4 w=4.0
j4162 1 1262 1263 0 jfet04 l=1.2 w=20.0
j4163 1 1264 0 0 jfet04 l=2.0 w=20.0
j4164 1 1265 1266 0 jfet04 l=1.2 w=20.0
j4165 1263 1263 1267 0 jfet16 l=1.6 w=3.6
j4166 0 1264 1 0 jfet04 l=2.0 w=20.0
j4167 1266 1266 1268 0 jfet16 l=1.6 w=4.0
j4168 1267 1267 1259 0 jfet16 l=1.6 w=3.6
j4169 1268 1268 1269 0 jfet16 l=1.6 w=4.0
j4170 1 1264 0 0 jfet04 l=2.0 w=20.0
j4171 1259 1269 0 0 jfet04 l=1.2 w=20.0
j4172 1269 1269 0 0 jfet04 l=1.2 w=20.0
j4173 0 1264 1270 0 jfet04 l=2.0 w=20.0
j4174 1270 1264 0 0 jfet04 l=2.0 w=20.0
j4175 0 1264 1270 0 jfet04 l=2.0 w=20.0
j4176 1270 1081 1265 0 jfet04 l=1.6 w=50.0
j4177 1270 1271 1262 0 jfet04 l=1.6 w=50.0
j4178 1262 1271 1270 0 jfet04 l=1.6 w=50.0
j4179 1270 1271 1262 0 jfet04 l=1.6 w=50.0

j4180 1265 1081 1270 0 jfet04 l=1.6 w=50.0
j4181 1270 1081 1265 0 jfet04 l=1.6 w=50.0
j4182 1262 1 1262 248 dio16 l=1.6 w=3.2
j4183 1265 1 1265 248 dio16 l=1.6 w=3.2
j4184 1 1271 1 248 dio16 l=1.2 w=47.2
j4185 1 1271 1 248 dio16 l=1.2 w=50.0
j4186 1 1271 1 248 dio16 l=1.2 w=50.0
j4187 1 1271 1 248 dio16 l=1.2 w=50.0
j4188 1 1271 1 248 dio16 l=1.2 w=50.0
j4189 1 1271 1 248 dio16 l=1.2 w=50.0
j4190 1271 0 1271 248 dio16 l=1.2 w=38.0
j4191 1271 0 1271 248 dio16 l=1.2 w=50.0
j4192 1271 0 1271 248 dio16 l=1.2 w=50.0
j4193 1271 0 1271 248 dio16 l=1.2 w=50.0
j4194 1271 0 1271 248 dio16 l=1.2 w=50.0
j4195 1271 0 1271 248 dio16 l=1.2 w=50.0
j4196 1 1272 1272 0 jfet16 l=1.2 w=3.2
j4197 1273 1273 1 0 jfet16 l=1.2 w=3.2
j4198 1 1274 1274 0 jfet16 l=1.2 w=3.2
j4199 1275 1275 1 0 jfet16 l=1.2 w=3.2
j4200 1 1276 1276 0 jfet16 l=1.2 w=3.2
j4201 1277 1277 1 0 jfet16 l=1.2 w=3.2
j4202 0 1278 1272 0 jfet04 l=1.2 w=48.0
j4203 1279 1278 0 0 jfet04 l=1.2 w=48.0
j4204 1 1272 1279 0 jfet04 l=1.2 w=48.0
j4205 1279 1273 1 0 jfet04 l=1.2 w=48.0
j4206 0 1278 1279 0 jfet04 l=1.2 w=48.0
j4207 1273 1278 0 0 jfet04 l=1.2 w=48.0
j4208 0 1279 1274 0 jfet04 l=1.2 w=48.0
j4209 296 1279 0 0 jfet04 l=1.2 w=48.0
j4210 1 1274 296 0 jfet04 l=1.2 w=48.0
j4211 296 1275 1 0 jfet04 l=1.2 w=48.0
j4212 0 1279 296 0 jfet04 l=1.2 w=48.0
j4213 1275 1279 0 0 jfet04 l=1.2 w=48.0
j4214 0 1279 1276 0 jfet04 l=1.2 w=48.0
j4215 296 1279 0 0 jfet04 l=1.2 w=48.0
j4216 1 1276 296 0 jfet04 l=1.2 w=48.0
j4217 296 1277 1 0 jfet04 l=1.2 w=48.0
j4218 0 1279 296 0 jfet04 l=1.2 w=48.0
j4219 1277 1279 0 0 jfet04 l=1.2 w=48.0
j4220 0 1280 1278 0 jfet04 l=1.2 w=38.4
j4221 0 1278 1281 0 jfet04 l=1.2 w=19.2
j4222 0 1280 1282 0 jfet04 l=1.2 w=19.2
j4223 1278 1282 1 0 jfet16 l=1.6 w=4.0
j4224 1281 1282 1281 248 dio16 l=1.2 w=2.4
j4225 1282 1282 1 0 jfet16 l=2.4 w=4.0
j4226 1 1283 1284 0 jfet04 l=1.2 w=20.0
j4227 1 1285 0 0 jfet04 l=2.0 w=20.0
j4228 1 1286 1287 0 jfet04 l=1.2 w=20.0
j4229 1284 1284 1288 0 jfet16 l=1.6 w=3.6
j4230 0 1285 1 0 jfet04 l=2.0 w=20.0

j4231 1287 1287 1289 0 jfet16 l=1.6 w=4.0
j4232 1288 1288 1280 0 jfet16 l=1.6 w=3.6
j4233 1289 1289 1290 0 jfet16 l=1.6 w=4.0
j4234 1 1285 0 0 jfet04 l=2.0 w=20.0
j4235 1280 1290 0 0 jfet04 l=1.2 w=20.0
j4236 1290 1290 0 0 jfet04 l=1.2 w=20.0
j4237 0 1285 1291 0 jfet04 l=2.0 w=20.0
j4238 1291 1285 0 0 jfet04 l=2.0 w=20.0
j4239 0 1285 1291 0 jfet04 l=2.0 w=20.0
j4240 1291 1081 1286 0 jfet04 l=1.6 w=50.0
j4241 1291 1292 1283 0 jfet04 l=1.6 w=50.0
j4242 1283 1292 1291 0 jfet04 l=1.6 w=50.0
j4243 1291 1292 1283 0 jfet04 l=1.6 w=50.0
j4244 1286 1081 1291 0 jfet04 l=1.6 w=50.0
j4245 1291 1081 1286 0 jfet04 l=1.6 w=50.0
j4246 1283 1 1283 248 dio16 l=1.6 w=3.2
j4247 1286 1 1286 248 dio16 l=1.6 w=3.2
j4248 1 1292 1 248 dio16 l=1.2 w=47.2
j4249 1 1292 1 248 dio16 l=1.2 w=50.0
j4250 1 1292 1 248 dio16 l=1.2 w=50.0
j4251 1 1292 1 248 dio16 l=1.2 w=50.0
j4252 1 1292 1 248 dio16 l=1.2 w=50.0
j4253 1 1292 1 248 dio16 l=1.2 w=50.0
j4254 1292 0 1292 248 dio16 l=1.2 w=38.0
j4255 1292 0 1292 248 dio16 l=1.2 w=50.0
j4256 1292 0 1292 248 dio16 l=1.2 w=50.0
j4257 1292 0 1292 248 dio16 l=1.2 w=50.0
j4258 1292 0 1292 248 dio16 l=1.2 w=50.0
j4259 1292 0 1292 248 dio16 l=1.2 w=50.0
j4260 1 1293 1293 0 jfet16 l=1.2 w=3.2
j4261 1294 1294 1 0 jfet16 l=1.2 w=3.2
j4262 1 1295 1295 0 jfet16 l=1.2 w=3.2
j4263 1296 1296 1 0 jfet16 l=1.2 w=3.2
j4264 1 1297 1297 0 jfet16 l=1.2 w=3.2
j4265 1298 1298 1 0 jfet16 l=1.2 w=3.2
j4266 0 1299 1293 0 jfet04 l=1.2 w=48.0
j4267 1300 1299 0 0 jfet04 l=1.2 w=48.0
j4268 1 1293 1300 0 jfet04 l=1.2 w=48.0
j4269 1300 1294 1 0 jfet04 l=1.2 w=48.0
j4270 0 1299 1300 0 jfet04 l=1.2 w=48.0
j4271 1294 1299 0 0 jfet04 l=1.2 w=48.0
j4272 0 1300 1295 0 jfet04 l=1.2 w=48.0
j4273 822 1300 0 0 jfet04 l=1.2 w=48.0
j4274 1 1295 822 0 jfet04 l=1.2 w=48.0
j4275 822 1296 1 0 jfet04 l=1.2 w=48.0
j4276 0 1300 822 0 jfet04 l=1.2 w=48.0
j4277 1296 1300 0 0 jfet04 l=1.2 w=48.0
j4278 0 1300 1297 0 jfet04 l=1.2 w=48.0
j4279 822 1300 0 0 jfet04 l=1.2 w=48.0
j4280 1 1297 822 0 jfet04 l=1.2 w=48.0
j4281 822 1298 1 0 jfet04 l=1.2 w=48.0

j4282 0 1300 822 0 jfet04 l=1.2 w=48.0
j4283 1298 1300 0 0 jfet04 l=1.2 w=48.0
j4284 0 1301 1299 0 jfet04 l=1.2 w=38.4
j4285 0 1299 1302 0 jfet04 l=1.2 w=19.2
j4286 0 1301 1303 0 jfet04 l=1.2 w=19.2
j4287 1299 1303 1 0 jfet16 l=1.6 w=4.0
j4288 1302 1303 1302 248 dio16 l=1.2 w=2.4
j4289 1303 1303 1 0 jfet16 l=2.4 w=4.0
j4290 1 1304 1305 0 jfet04 l=1.2 w=20.0
j4291 1 1306 0 0 jfet04 l=2.0 w=20.0
j4292 1 1307 1308 0 jfet04 l=1.2 w=20.0
j4293 1305 1305 1309 0 jfet16 l=1.6 w=3.6
j4294 0 1306 1 0 jfet04 l=2.0 w=20.0
j4295 1308 1308 1310 0 jfet16 l=1.6 w=4.0
j4296 1309 1309 1301 0 jfet16 l=1.6 w=3.6
j4297 1310 1310 1311 0 jfet16 l=1.6 w=4.0
j4298 1 1306 0 0 jfet04 l=2.0 w=20.0
j4299 1301 1311 0 0 jfet04 l=1.2 w=20.0
j4300 1311 1311 0 0 jfet04 l=1.2 w=20.0
j4301 0 1306 1312 0 jfet04 l=2.0 w=20.0
j4302 1312 1306 0 0 jfet04 l=2.0 w=20.0
j4303 0 1306 1312 0 jfet04 l=2.0 w=20.0
j4304 1312 1081 1307 0 jfet04 l=1.6 w=50.0
j4305 1312 1313 1304 0 jfet04 l=1.6 w=50.0
j4306 1304 1313 1312 0 jfet04 l=1.6 w=50.0
j4307 1312 1313 1304 0 jfet04 l=1.6 w=50.0
j4308 1307 1081 1312 0 jfet04 l=1.6 w=50.0
j4309 1312 1081 1307 0 jfet04 l=1.6 w=50.0
j4310 1304 1 1304 248 dio16 l=1.6 w=3.2
j4311 1307 1 1307 248 dio16 l=1.6 w=3.2
j4312 1 1313 1 248 dio16 l=1.2 w=47.2
j4313 1 1313 1 248 dio16 l=1.2 w=50.0
j4314 1 1313 1 248 dio16 l=1.2 w=50.0
j4315 1 1313 1 248 dio16 l=1.2 w=50.0
j4316 1 1313 1 248 dio16 l=1.2 w=50.0
j4317 1 1313 1 248 dio16 l=1.2 w=50.0
j4318 1313 0 1313 248 dio16 l=1.2 w=38.0
j4319 1313 0 1313 248 dio16 l=1.2 w=50.0
j4320 1313 0 1313 248 dio16 l=1.2 w=50.0
j4321 1313 0 1313 248 dio16 l=1.2 w=50.0
j4322 1313 0 1313 248 dio16 l=1.2 w=50.0
j4323 1313 0 1313 248 dio16 l=1.2 w=50.0
r0 1 1244 1714.29
r1 1 1181 1714.29
r2 1 1265 1714.29
r3 1 1097 1714.29
r4 1 1243 2350
r5 1 1286 1714.29
r6 1 1180 2350
r7 1 1264 2350
r8 1 1096 2350

r9 1 1136 1714.29
r10 1 1285 2350
r11 1 1202 1714.29
r12 1 1307 1714.29
r13 1 1201 2350
r14 1 1220 1714.29
r15 1 1306 2350
r16 1 1075 1714.29
r17 1 1115 1714.29
r18 1 1241 1714.29
r19 1 1160 1714.29
r20 1 1178 1714.29
r21 1 1262 1714.29
r22 1 1094 1714.29
r23 1 1159 2350
r24 1 1139 1714.29
r25 1 1283 1714.29
r26 1 1074 2350
r27 1 1117 1 2350
r28 1 1138 2350
r29 1 1199 1714.29
r30 1 1223 1714.29
r31 1 1304 1714.29
r32 1 1072 1714.29
r33 1 1118 1 1714.29
r34 1 1222 2350
r35 1 1157 1714.29
** node: 1313 = a1!
** node: 1292 = inclk!
** node: 1271 = d0!
** node: 1250 = d1!
** node: 1229 = d2!
** node: 1208 = d3!
** node: 1187 = a0!
** node: 1166 = das!
** node: 1145 = a2!
** node: 1124 = refresh!
** node: 1103 = read!
** node: 1082 = write!
** node: 1081 = rvref!
** node: 1014 = cm1_0/o7
** node: 993 = cm1_0/read
** node: 992 = cm1_0/write
** node: 965 = cm1_0/d3
** node: 929 = cm1_0/3cd0
** node: 927 = cm1_0/3rc6
** node: 926 = cm1_0/3rc4
** node: 916 = cm1_0/3rc2
** node: 907 = cm1_0/3ep
** node: 906 = cm1_0/3rc0
** node: 901 = cm1_0/a2

** node: 857 = cm1_0/3epd
** node: 853 = cm1_0/3opd
** node: 822 = cm1_0/a1
** node: 816 = cm1_0/q2
** node: 789 = cm1_0/3opu
** node: 786 = cm1_0/3cde
** node: 788 = cm1_0/3rc7
** node: 787 = cm1_0/3rc5
** node: 790 = cm1_0/3rc3
** node: 849 = cm1_0/3rc1
** node: 784 = cm1_0/3ebio
** node: 779 = cm1_0/3obio
** node: 651 = cm1_0/q1
** node: 600 = cm1_0/ao1
** node: 599 = cm1_0/ao2
** node: 604 = cm1_0/d2
** node: 548 = cm1_0/2cd0
** node: 546 = cm1_0/2rc6
** node: 545 = cm1_0/2rc4
** node: 523 = cm1_0/2rc2
** node: 507 = cm1_0/2epu
** node: 512 = cm1_0/q0
** node: 506 = cm1_0/2rc0
** node: 483 = cm1_0/2epd
** node: 482 = cm1_0/2opd
** node: 472 = cm1_0/q0n
** node: 473 = cm1_0/q1n
** node: 467 = cm1_0/q2n
** node: 466 = cm1_0/refresh
** node: 598 = cm1_0/mref
** node: 462 = cm1_0/2opu
** node: 459 = cm1_0/2cde
** node: 461 = cm1_0/2rc7
** node: 460 = cm1_0/2rc5
** node: 463 = cm1_0/2rc3
** node: 464 = cm1_0/2rc1
** node: 439 = cm1_0/ao0
** node: 455 = cm1_0/2ebio
** node: 450 = cm1_0/2obio
** node: 372 = cm1_0/d1
** node: 360 = cm1_0/1cd0
** node: 359 = cm1_0/1rc6
** node: 358 = cm1_0/1rc4
** node: 347 = cm1_0/1rc2
** node: 338 = cm1_0/1epu
** node: 337 = cm1_0/1rc0
** node: 329 = cm1_0/1epd
** node: 318 = cm1_0/1opd
** node: 315 = cm1_0/1opu
** node: 312 = cm1_0/1cde
** node: 314 = cm1_0/1rc7

** node: 313 = cm1_0/1rc5
** node: 316 = cm1_0/1rc3
** node: 317 = cm1_0/1rc1
** node: 297 = cm1_0/ph1
** node: 296 = cm1_0/inclk
** node: 311 = cm1_0/lebio
** node: 306 = cm1_0/lobio
** node: 253 = cm1_0/a0
** node: 244 = cm1_0/mw
** node: 243 = cm1_0/ph2
** node: 227 = cm1_0/das
** node: 225 = cm1_0/d0
** node: 218 = cm1_0/0cd0
** node: 219 = cm1_0/od
** node: 216 = cm1_0/0rc6
** node: 215 = cm1_0/0rc4
** node: 217 = cm1_0/da6
** node: 214 = cm1_0/da4
** node: 206 = cm1_0/0rc2
** node: 205 = cm1_0/da2
** node: 195 = cm1_0/0epu
** node: 194 = cm1_0/da0
** node: 193 = cm1_0/0rc0
** node: 192 = cm1_0/0epd
** node: 202 = cm1_0/mr
** node: 191 = cm1_0/ph2ld
** node: 190 = cm1_0/0opd
** node: 188 = cm1_0/da1
** node: 187 = cm1_0/da3
** node: 184 = cm1_0/0op
** node: 183 = cm1_0/ev
** node: 182 = cm1_0/da7
** node: 179 = cm1_0/da5
** node: 177 = cm1_0/ph1l
** node: 178 = cm1_0/cde
** node: 181 = cm1_0/0rc7
** node: 180 = cm1_0/0rc5
** node: 186 = cm1_0/0rc3
** node: 189 = cm1_0/0rc1
** node: 175 = cm1_0/ev
** node: 174 = cm1_0/0ebio
** node: 169 = cm1_0/od
** node: 168 = cm1_0/0obio
** node: 141 = cm1_0/o0
** node: 147 = do0!
** node: 133 = cm1_0/o1
** node: 139 = do1!
** node: 125 = cm1_0/o2
** node: 131 = do2!
** node: 117 = cm1_0/o3
** node: 123 = do3!

** node: 109 = cm1_0/mbsy
** node: 115 = mbsy!
** node: 0 = gnd!
** node: 1 = vdd!
** node: 101 = cm1_0/drdy
** node: 107 = drdy!
** node: 176 = vrefd!
** node: 185 = vrefb!
** node: 248 = vss!
c0 178 0 70ff
c1 218 0 70ff
c2 312 0 70ff
c3 360 0 70ff
c4 459 0 70ff
c5 548 0 70ff
c6 786 0 70ff
c7 929 0 70ff

c100 189 0 620ff
c101 186 0 620ff
c102 180 0 620ff
c103 181 0 620ff
c104 193 0 620ff
c105 206 0 620ff
c106 215 0 620ff
c107 216 0 620ff

c110 317 0 620ff
c111 316 0 620ff
c112 313 0 620ff
c113 314 0 620ff
c114 337 0 620ff
c115 347 0 620ff
c116 359 0 620ff
c117 358 0 620ff

c120 464 0 620ff
c121 463 0 620ff
c122 460 0 620ff
c123 461 0 620ff
c124 506 0 620ff
c125 523 0 620ff
c126 545 0 620ff
c127 546 0 620ff

c130 849 0 620ff
c131 790 0 620ff
c132 787 0 620ff
c133 788 0 620ff
c134 906 0 620ff
c135 916 0 620ff

c136 926 0 620ff
c137 927 0 620ff

* don't forget the terminating resistors on each output pad

r100 147 0 50

r101 139 0 50

r102 131 0 50

r103 123 0 50

r104 107 0 50

r105 115 0 50

* ***** hspice version *****

* include vitesse hgaas3 models and parameters for hspice.

* power supply

vds 1 0 dc 2.0v

vrefb 185 0 dc 0.7v

vrefd 176 0 dc 0.26v

vreref 1081 0 dc 0.70v

vss 248 0 dc -2.5v

* signal input

*

*remember that the inputs are ecl re: l=0.4v h=1.1v

*remember that outputs are ecl too!

*

vinclk 1292 0 pulse(1.1 0.4 0ps 100ps 100ps 2100ps 4200ps)

va0 1187 0 1.1v \$ memory address bit 0
val 1313 0 0.4v \$ memory address bit 1
va2 1145 0 1.1v \$ memory address bit 2

vd0 1271 0 1.1v \$ memory data bit 0

vd1 1250 0 0.4v \$ memory data bit 1

vd2 1229 0 1.1v \$ memory data bit 2

vd3 1208 0 1.1v \$ memory data bit 3

vdas 1166 0 1.1v \$ memory data strobe

vwrite 1082 0 pulse(0.4 1.1 2.8ns 100ps 100ps 5200ps 1000ms) \$ memory writ
e

vread 1103 0 pulse(0.4 1.1 3ns 100ps 100ps 8000ps 1000ms) \$ memory read

*vrefresh 1124 0 0.4v

vrefresh 1124 0 pulse(0.4 1.1 12ns 100ps 100ps 4200ps 1000ms) \$ test eol co
m

```

* following .ic line initializes the refresh control counter to 3 zeroes
* simulation purposes only
* q0      q1      q2      q0n     q1n     q2n
.ic v(512)=0.0 v(651)=0.0 v(816)=0.0 v(472)=0.63 v(473)=0.63 v(467)=0.63
* mref
+ v(598)=0.0
*.temp 85.0
.tran 500ps 60ns

```

```

.measure tran vds_avgpwr avg p(vds) from 0.0ns to 60ns
.measure tran vrefb_avgpwr avg p(vrefb) from 0.0ns to 60ns
.measure tran vrefd_avgpwr avg p(vrefd) from 0.0ns to 60ns
.measure tran vrvrif_avgpwr avg p(vrvrif) from 0.0ns to 60ns
.measure tran vss_avgpwr avg p(vss) from 0.0ns to 60ns

```

```

*
          80 columns->>*
.probe inclk=v(1292) a0=v(1187) a1=v(1313) a2=v(1145) d0=v(1271) d1=v(1250)
+ d2=v(1229) d3=v(1208) das=v(1166) write=v(1082) read=v(1103) refresh=v(1124)
+ mrefresh=v(598) mwwrite=v(244) mread=v(202)
+ ma3cdo=v(929) ma3cde=v(786) ma3rc6=v(927) ma3rc4=v(926)
+ ma3rc2=v(916) ma3rc0=v(906) ma3rc7=v(788) ma3rc5=v(787) ma3rc3=v(790)
+ ma3rc1=v(849) ma3ebio=v(784) ma3obio=v(779) ma3epu=v(907) ma3epd=v(857)
+ ma3opu=v(789) ma3opd=v(853) q0=v(512)

```

```

.options fast ft=0.95 fs=.95 imin=16.0 imax=16.0 delmax=1.0s rmax=8.0
+ scale=1e-06 brief=0 nopage measout post probe gmindc=1e-11 captab acct
*.options scale=1e-06 probe post gmindc=1e-11 acct captab
.end

```

```

**warning** the fast option decreases the cpu time but results may be
less accurate.
****fast option sets default value of the options:
dvdt= 1      rmax=  8.00    fs= 950.00m   ft= 950.00m
relvar= 400.00m absvar= 1.00 relmos= 100.00m absmos= 10.00u
**warning** could not find branch element 0:vrvrif
branch - output ignored
** spice file created for circuit gaasdram0 1/10/93 mike morris
***** operating point information  tnom= 25.000 temp= 25.000
*****
***** operating point status is voltage simulation time is 0.
node =voltage node =voltage node =voltage

```

```

+0:1    = 2.0000 0:100    = 61.5008m 0:101    = 668.5881m
+0:102   = 1.9874 0:103    = 63.4356m 0:104    = 1.7750
+0:105   = 1.3406 0:106    = 1.3028 0:107    = 1.1799
+0:108   = 635.3582m 0:109    = 52.0500m 0:110    = 65.6886m
+0:111   = 633.3473m 0:112    = 110.9801m 0:113    = 1.4638

```

+0:114	= 1.4226	0:115	= 23.0831m	0:116	= 63.1546m
+0:117	= 646.3142m	0:118	= 1.9870	0:119	= 65.5267m
+0:120	= 1.7749	0:121	= 1.3406	0:122	= 1.3028
+0:123	= 1.1799	0:124	= 63.1546m	0:125	= 646.3142m
+0:126	= 1.9870	0:127	= 65.5267m	0:128	= 1.7749
+0:129	= 1.3406	0:130	= 1.3028	0:131	= 1.1799
+0:132	= 63.1546m	0:133	= 646.3142m	0:134	= 1.9870
+0:135	= 65.5267m	0:136	= 1.7749	0:137	= 1.3406
+0:138	= 1.3028	0:139	= 1.1799	0:140	= 63.1546m
+0:141	= 646.3142m	0:142	= 1.9870	0:143	= 65.5267m
+0:144	= 1.7749	0:145	= 1.3406	0:146	= 1.3028
+0:147	= 1.1799	0:148	= 644.3156m	0:149	= 653.4293m
+0:150	= 52.1099m	0:151	= 53.0832m	0:152	= 31.7692m
+0:153	= 53.0833m	0:154	= 52.1099m	0:155	= 644.3155m
+0:156	= 653.4296m	0:157	= 31.7693m	0:158	= 642.1434m
+0:159	= 642.1432m	0:160	= 651.2168m	0:161	= 53.0833m
+0:162	= 25.0740m	0:163	= 642.1434m	0:164	= 642.1432m
+0:165	= 651.2166m	0:166	= 53.0832m	0:167	= 25.0740m
+0:168	= 283.3468m	0:169	= 15.0105m	0:170	= 649.5537m
+0:171	= 636.6299m	0:172	= 636.6297m	0:173	= 649.5538m
+0:174	= 283.3478m	0:175	= 14.8309m	0:176	= 260.0000m
+0:177	= 47.0991m	0:178	= 260.0000m	0:179	= -1.2102
+0:180	= 185.3334m	0:181	= 185.3334m	0:182	= -1.2102
+0:183	= -1.2102	0:184	= -1.2102	0:185	= 700.0000m
+0:186	= 185.3334m	0:187	= -1.2102	0:188	= -1.2102
+0:189	= 185.3334m	0:190	= 26.2262m	0:191	= -1.2102
+0:192	= 23.1826m	0:193	= 185.3336m	0:194	= -1.2102
+0:195	= -1.2102	0:196	= 658.5029m	0:197	= 52.0502m
+0:198	= 658.7224m	0:199	= 52.0553m	0:200	= 653.5485m
+0:201	= 653.5488m	0:202	= 51.9710m	0:203	= 32.4441m
+0:204	= 1.3252	0:205	= -1.2102	0:206	= 185.3336m
+0:207	= 62.1464m	0:208	= 1.2617	0:209	= 654.8023m
+0:210	= 94.4918m	0:211	= 720.2099m	0:212	= 711.4147m
+0:213	= 62.4027m	0:214	= -1.2102	0:215	= 185.3336m
+0:216	= 185.3336m	0:217	= -1.2102	0:218	= 260.0000m
+0:219	= -1.2102	0:220	= 83.7791m	0:221	= 614.6034m
+0:222	= 681.1434m	0:223	= 81.2916m	0:224	= 61.2124m
+0:225	= 706.7093m	0:226	= 53.6483m	0:227	= 660.6934m
+0:228	= 44.1940m	0:229	= 18.5576m	0:230	= 51.1112m
+0:231	= 650.4577m	0:232	= 650.3010m	0:233	= 650.5376m
+0:234	= 650.4577m	0:235	= 651.5281m	0:236	= 56.9511m
+0:237	= 651.5281m	0:238	= 651.6083m	0:239	= 26.2368m
+0:240	= 1.9864	0:241	= 91.2977m	0:242	= 52.0122m
+0:243	= 21.1598m	0:244	= 52.0131m	0:245	= 1.4151
+0:246	= 687.7530m	0:247	= 281.0546m	0:248	= -2.5000
+0:249	= -2.1776	0:250	= -464.5912m	0:251	= -1.8551
+0:252	= -1.5327	0:253	= 654.6080m	0:254	= 52.0122m
+0:255	= 651.3674m	0:256	= 651.6047m	0:257	= 651.5245m
+0:258	= 52.0122m	0:259	= 56.9511m	0:260	= 653.5411m
+0:261	= 653.6218m	0:262	= 32.4197m	0:263	= 1.9855
+0:264	= -464.6009m	0:265	= -1.5327	0:266	= 687.4029m

+0:267	= 1.4146 0:268	= 281.0448m 0:269	= -1.8551
+0:270	= 91.2850m 0:271	= -2.1776 0:272	= 644.3159m
+0:273	= 653.4293m 0:274	= 52.1099m 0:275	= 53.0832m
+0:276	= 31.7693m 0:277	= 53.0833m 0:278	= 52.1099m
+0:279	= 644.3156m 0:280	= 653.4296m 0:281	= 31.7693m
+0:282	= 642.1437m 0:283	= 642.1433m 0:284	= 651.2168m
+0:285	= 53.0833m 0:286	= 25.0740m 0:287	= 642.1437m
+0:288	= 642.1433m 0:289	= 651.2166m 0:290	= 53.0832m
+0:291	= 25.0740m 0:292	= 1.4024 0:293	= 52.5036m
+0:294	= 1.3308 0:295	= 61.1855m 0:296	= 664.3093m
+0:297	= 741.0191m 0:298	= 48.0693m 0:299	= 667.2192m
+0:300	= 54.1981m 0:301	= 52.2948m 0:302	= 20.1113m
+0:303	= 1.3020 0:304	= 628.5119m 0:305	= 10.2774m
+0:306	= 283.3449m 0:307	= 649.5538m 0:308	= 636.6299m
+0:309	= 636.6297m 0:310	= 649.5541m 0:311	= 283.3472m
+0:312	= 260.0000m 0:313	= 185.3330m 0:314	= 185.3330m
+0:315	= -1.2102 0:316	= 185.3330m 0:317	= 185.3330m
+0:318	= 32.4197m 0:319	= 52.5036m 0:320	= 633.5094m
+0:321	= 32.0844m 0:322	= 610.7009m 0:323	= 610.6642m
+0:324	= 26.7721m 0:325	= 6.6963m 0:326	= 1.9887
+0:327	= -464.5655m 0:328	= 1.4024 0:329	= 26.2368m
+0:330	= 77.1805m 0:331	= 1.9341 0:332	= -1.5327
+0:333	= -230.1995m 0:334	= -939.2934m 0:335	= 1.5584
+0:336	= -1.8632 0:337	= 185.3334m 0:338	= -1.2102
+0:339	= 658.5029m 0:340	= 52.0502m 0:341	= 658.7224m
+0:342	= 52.0553m 0:343	= 653.5485m 0:344	= 653.5488m
+0:345	= 32.4441m 0:346	= 1.3252 0:347	= 185.3334m
+0:348	= 802.7575m 0:349	= -1.2265 0:350	= 62.1464m
+0:351	= 1.2617 0:352	= 654.8023m 0:353	= 94.4918m
+0:354	= 720.2099m 0:355	= 711.4147m 0:356	= 62.4027m
+0:357	= -589.6757m 0:358	= 185.3334m 0:359	= 185.3334m
+0:360	= 260.0000m 0:361	= 681.3352m 0:362	= 81.3768m
+0:363	= 78.4572m 0:364	= 614.6178m 0:365	= 678.4986m
+0:366	= 688.6339m 0:367	= 1.4163 0:368	= 281.0805m
+0:369	= -1.8551 0:370	= 91.3312m 0:371	= -2.1776
+0:372	= 21.4729m 0:373	= 558.0589m 0:374	= 51.1900m
+0:375	= 48.2828m 0:376	= 40.9551m 0:377	= 651.5281m
+0:378	= 56.9477m 0:379	= 651.6083m 0:380	= 651.5281m
+0:381	= 650.4577m 0:382	= 650.3003m 0:383	= 650.4577m
+0:384	= 650.5376m 0:385	= 23.1826m 0:386	= 1.9868
+0:387	= 91.3036m 0:388	= 52.0122m 0:389	= 1.4153
+0:390	= 687.9123m 0:391	= 281.0592m 0:392	= -2.1776
+0:393	= -464.5867m 0:394	= -1.8551 0:395	= -1.5327
+0:396	= 52.0122m 0:397	= 56.9477m 0:398	= 653.6218m
+0:399	= 653.5411m 0:400	= 52.0122m 0:401	= 651.3667m
+0:402	= 651.5245m 0:403	= 651.6047m 0:404	= 26.2262m
+0:405	= 1.9864 0:406	= -464.5912m 0:407	= -1.5327
+0:408	= 687.7536m 0:409	= 1.4151 0:410	= 281.0546m
+0:411	= -1.8551 0:412	= 91.2978m 0:413	= -2.1776
+0:414	= 644.3156m 0:415	= 653.4293m 0:416	= 52.1099m
+0:417	= 53.0832m 0:418	= 31.7692m 0:419	= 53.0833m

+0:420	= 52.1099m 0:421	= 644.3155m 0:422	= 653.4296m
+0:423	= 31.7693m 0:424	= 642.1434m 0:425	= 642.1432m
+0:426	= 651.2168m 0:427	= 53.0833m 0:428	= 25.0740m
+0:429	= 642.1434m 0:430	= 642.1432m 0:431	= 651.2166m
+0:432	= 53.0832m 0:433	= 25.0740m 0:434	= 63.7170m
+0:435	= 26.4851m 0:436	= 1.3150 0:437	= 1.3154
+0:438	= 1.3155 0:439	= 591.6209m 0:440	= 648.8233m
+0:441	= 32.2745m 0:442	= 648.9187m 0:443	= 1.9879
+0:444	= 91.3185m 0:445	= 648.9397m 0:446	= 1.4158
+0:447	= 688.3053m 0:448	= 281.0706m 0:449	= -2.1776
+0:450	= 283.3468m 0:451	= 649.5537m 0:452	= 636.6299m
+0:453	= 636.6297m 0:454	= 649.5538m 0:455	= 283.3478m
+0:456	= -464.5753m 0:457	= -1.8551 0:458	= -1.5327
+0:459	= 260.0000m 0:460	= 185.3334m 0:461	= 185.3334m
+0:462	= -1.2102 0:463	= 185.3334m 0:464	= 185.3334m
+0:465	= 653.1676m 0:466	= 21.4729m 0:467	= 629.9968m
+0:468	= 57.5154m 0:469	= 10.6195m 0:470	= 10.6178m
+0:471	= 57.5170m 0:472	= 629.9885m 0:473	= 629.9927m
+0:474	= 57.5162m 0:475	= 10.6186m 0:476	= 16.4768m
+0:477	= 54.9190m 0:478	= 1.3579 0:479	= 693.3843m
+0:480	= 59.0264m 0:481	= 32.3384m 0:482	= 26.2262m
+0:483	= 23.1826m 0:484	= 53.9676m 0:485	= 658.7393m
+0:486	= 52.0114m 0:487	= 658.7911m 0:488	= 54.9711m
+0:489	= 52.0114m 0:490	= 658.5363m 0:491	= 52.0509m
+0:492	= 651.5307m 0:493	= 651.5887m 0:494	= 651.5307m
+0:495	= 26.2446m 0:496	= 636.6116m 0:497	= 653.5993m
+0:498	= 653.5409m 0:499	= 77.1806m 0:500	= 32.4194m
+0:501	= 624.0322m 0:502	= 54.9711m 0:503	= 53.0853m
+0:504	= 658.5204m 0:505	= 52.0506m 0:506	= 185.3336m
+0:507	= -1.2102 0:508	= 678.3256m 0:509	= 78.2660m
+0:510	= 1.2803 0:511	= 657.5160m 0:512	= 17.6214u
+0:513	= 624.0324m 0:514	= 52.0443m 0:515	= 658.5029m
+0:516	= 52.0502m 0:517	= 658.7224m 0:518	= 52.0553m
+0:519	= 653.5485m 0:520	= 653.5488m 0:521	= 32.4441m
+0:522	= 1.3252 0:523	= 185.3336m 0:524	= 77.1806m
+0:525	= 1.8535 0:526	= 79.2828m 0:527	= 48.0917m
+0:528	= 1.2832 0:529	= 667.7719m 0:530	= 62.1464m
+0:531	= 1.2617 0:532	= 654.8023m 0:533	= 94.4918m
+0:534	= 720.2099m 0:535	= 711.4147m 0:536	= 62.4027m
+0:537	= 1.3158 0:538	= 649.2803m 0:539	= 68.5971m
+0:540	= 5.2838m 0:541	= 649.3014m 0:542	= 1.3159
+0:543	= 33.0159m 0:544	= 1.9878 0:545	= 185.3336m
+0:546	= 185.3336m 0:547	= -464.5756m 0:548	= 260.0000m
+0:549	= 83.7791m 0:550	= 614.6034m 0:551	= -1.5327
+0:552	= 681.1434m 0:553	= 81.2916m 0:554	= 688.2975m
+0:555	= 1.4158 0:556	= 281.0704m 0:557	= 61.2124m
+0:558	= -1.8551 0:559	= 91.3182m 0:560	= -2.1776
+0:561	= 60.4818m 0:562	= 607.0150m 0:563	= 63.7170m
+0:564	= 1.3562 0:565	= 1.3558 0:566	= 63.1800m
+0:567	= 1.3557 0:568	= 39.0328m 0:569	= 652.7337m
+0:570	= 54.9364m 0:571	= 55.1515m 0:572	= 1.3508

+0:573	= 77.1806m 0:574	= 54.9711m 0:575	= 53.0853m
+0:576	= 658.2338m 0:577	= 651.5915m 0:578	= 651.6421m
+0:579	= 651.5335m 0:580	= 26.2528m 0:581	= 53.9676m
+0:582	= 54.9711m 0:583	= 640.4275m 0:584	= 678.2869m
+0:585	= 635.3794m 0:586	= 53.9676m 0:587	= 658.7914m
+0:588	= 52.0127m 0:589	= 54.9711m 0:590	= 658.7911m
+0:591	= 52.0114m 0:592	= 527.3246m 0:593	= 16.3459m
+0:594	= 15.1940m 0:595	= 648.7895m 0:596	= 57.3109m
+0:597	= 685.5450m 0:598	= 9.9150u 0:599	= 601.4728m
+0:600	= 52.0502m 0:601	= 690.9985m 0:602	= 690.9036m
+0:603	= 6.8662m 0:604	= 706.7093m 0:605	= 53.6483m
+0:606	= 44.1940m 0:607	= 18.5576m 0:608	= 51.1112m
+0:609	= 650.4577m 0:610	= 650.3010m 0:611	= 650.5376m
+0:612	= 650.4577m 0:613	= 651.5281m 0:614	= 56.9511m
+0:615	= 651.5281m 0:616	= 651.6083m 0:617	= 26.2368m
+0:618	= 1.9864 0:619	= 91.2977m 0:620	= 52.0122m
+0:621	= 1.4151 0:622	= 687.7530m 0:623	= 281.0546m
+0:624	= -2.1776 0:625	= -464.5912m 0:626	= -1.8551
+0:627	= -1.5327 0:628	= 690.8888m 0:629	= 30.9592m
+0:630	= 653.6139m 0:631	= 653.6332m 0:632	= 32.4567m
+0:633	= 1.9855 0:634	= 91.2850m 0:635	= 658.2558m
+0:636	= 52.0448m 0:637	= 651.5307m 0:638	= 651.5887m
+0:639	= 651.5307m 0:640	= 26.2446m 0:641	= 636.6116m
+0:642	= 653.5993m 0:643	= 653.5409m 0:644	= 77.1806m
+0:645	= 32.4194m 0:646	= 624.0322m 0:647	= 54.9711m
+0:648	= 53.0853m 0:649	= 658.5204m 0:650	= 52.0506m
+0:651	= 17.6214u 0:652	= 84.3188m 0:653	= 32.4435m
+0:654	= 52.0443m 0:655	= 1.3153 0:656	= 31.3318m
+0:657	= 691.5024m 0:658	= 691.7504m 0:659	= 43.7213m
+0:660	= 1.3571 0:661	= 1.3561 0:662	= 78.4523m
+0:663	= 48.2891m 0:664	= 1.3568 0:665	= 691.6940m
+0:666	= 691.5987m 0:667	= 1.3565 0:668	= 63.1800m
+0:669	= 6.8662m 0:670	= 5.2838m 0:671	= 68.5971m
+0:672	= 43.7222m 0:673	= 31.3369m 0:674	= 1.4146
+0:675	= 687.4007m 0:676	= 281.0448m 0:677	= -2.1776
+0:678	= -464.6010m 0:679	= -1.8551 0:680	= -1.5327
+0:681	= 1.3558 0:682	= 1.3555 0:683	= 1.3556
+0:684	= 1.3554 0:685	= 36.7628m 0:686	= 653.6131m
+0:687	= 653.6332m 0:688	= 32.4567m 0:689	= 1.9855
+0:690	= -464.6010m 0:691	= -1.5327 0:692	= 52.0122m
+0:693	= 651.3674m 0:694	= 651.6047m 0:695	= 651.5245m
+0:696	= 52.0122m 0:697	= 56.9511m 0:698	= 653.5411m
+0:699	= 653.6218m 0:700	= 32.4197m 0:701	= 1.9855
+0:702	= -464.6009m 0:703	= -1.5327 0:704	= 687.4029m
+0:705	= 1.4146 0:706	= 687.4007m 0:707	= 1.4146
+0:708	= 658.5039m 0:709	= 52.0122m 0:710	= 52.1389m
+0:711	= 658.5213m 0:712	= 52.0122m 0:713	= 658.7919m
+0:714	= 52.0151m 0:715	= 653.6593m 0:716	= 52.0502m
+0:717	= 653.6593m 0:718	= 32.4488m 0:719	= 51.9845m
+0:720	= 653.6576m 0:721	= 653.6067m 0:722	= 53.9669m
+0:723	= 77.1806m 0:724	= 54.9711m 0:725	= 53.0853m

+0:726	= 658.2338m 0:727	= 651.5915m 0:728	= 651.6421m
+0:729	= 651.5335m 0:730	= 26.2528m 0:731	= 53.9669m
+0:732	= 54.9711m 0:733	= 640.4275m 0:734	= 84.3312m
+0:735	= 690.6401m 0:736	= 690.5453m 0:737	= 690.5796m
+0:738	= 690.5305m 0:739	= 30.7740m 0:740	= 281.0448m
+0:741	= 281.0448m 0:742	= -1.8551 0:743	= 91.2850m
+0:744	= -2.1776 0:745	= -1.8551 0:746	= 644.3156m
+0:747	= 653.4293m 0:748	= 52.1099m 0:749	= 53.0832m
+0:750	= 91.2850m 0:751	= -2.1776 0:752	= 31.7692m
+0:753	= 53.0833m 0:754	= 52.1099m 0:755	= 644.3155m
+0:756	= 653.4296m 0:757	= 31.7693m 0:758	= 642.1434m
+0:759	= 642.1432m 0:760	= 651.2168m 0:761	= 53.0833m
+0:762	= 25.0740m 0:763	= 642.1434m 0:764	= 642.1432m
+0:765	= 651.2166m 0:766	= 53.0832m 0:767	= 25.0740m
+0:768	= 653.6143m 0:769	= 653.6332m 0:770	= 32.4568m
+0:771	= 1.9855 0:772	= 91.2850m 0:773	= 1.4146
+0:774	= 687.4007m 0:775	= 281.0448m 0:776	= -2.1776
+0:777	= -464.6010m 0:778	= -1.8551 0:779	= 283.3468m
+0:780	= 649.5537m 0:781	= 636.6299m 0:782	= 636.6297m
+0:783	= 649.5538m 0:784	= 283.3478m 0:785	= -1.5327
+0:786	= 260.0000m 0:787	= 185.3334m 0:788	= 185.3334m
+0:789	= -1.2102 0:790	= 185.3334m 0:791	= 53.9676m
+0:792	= 658.7914m 0:793	= 52.0127m 0:794	= 53.9669m
+0:795	= 658.7914m 0:796	= 52.0127m 0:797	= 54.9711m
+0:798	= 658.7911m 0:799	= 52.0114m 0:800	= 658.3020m
+0:801	= 52.0458m 0:802	= 651.5307m 0:803	= 651.5887m
+0:804	= 651.5307m 0:805	= 26.2446m 0:806	= 636.6116m
+0:807	= 653.5993m 0:808	= 653.5409m 0:809	= 77.1806m
+0:810	= 32.4194m 0:811	= 624.0322m 0:812	= 54.9711m
+0:813	= 53.0853m 0:814	= 658.5204m 0:815	= 52.0506m
+0:816	= 17.6214u 0:817	= 26.2522m 0:818	= 52.0443m
+0:819	= 658.5039m 0:820	= 84.3312m 0:821	= 658.7622m
+0:822	= 21.4729m 0:823	= 52.1389m 0:824	= 52.0142m
+0:825	= 653.6340m 0:826	= 653.6630m 0:827	= 32.4609m
+0:828	= 52.0502m 0:829	= 653.6593m 0:830	= 653.6593m
+0:831	= 32.4488m 0:832	= 658.5020m 0:833	= 1.3562
+0:834	= 691.0012m 0:835	= 690.9062m 0:836	= 1.3558
+0:837	= 1.3559 0:838	= 690.9406m 0:839	= 5.2838m
+0:840	= 68.5971m 0:841	= 39.0407m 0:842	= 30.9684m
+0:843	= 653.6139m 0:844	= 653.6332m 0:845	= 32.4567m
+0:846	= 1.9855 0:847	= -464.6010m 0:848	= -1.5327
+0:849	= 185.3334m 0:850	= 687.4007m 0:851	= 1.4146
+0:852	= 281.0448m 0:853	= 26.2262m 0:854	= -1.8551
+0:855	= 91.2850m 0:856	= -2.1776 0:857	= 23.1826m
+0:858	= 1.3568 0:859	= 63.1800m 0:860	= 64.9795m
+0:861	= 1.3564 0:862	= 43.7189m 0:863	= 658.5039m
+0:864	= 68.4778m 0:865	= 52.1389m 0:866	= 658.4439m
+0:867	= 68.4778m 0:868	= 658.7865m 0:869	= 51.9903m
+0:870	= 651.6419m 0:871	= 651.6419m 0:872	= 651.5913m
+0:873	= 53.9663m 0:874	= 77.1806m 0:875	= 54.9711m
+0:876	= 53.0853m 0:877	= 658.2338m 0:878	= 651.5915m

+0:879	= 651.6421m 0:880	= 651.5335m 0:881	= 26.2528m
+0:882	= 53.9663m 0:883	= 54.9711m 0:884	= 640.4275m
+0:885	= 653.6593m 0:886	= 52.0502m 0:887	= 653.6593m
+0:888	= 32.4488m 0:889	= 51.9828m 0:890	= 691.6929m
+0:891	= 6.8662m 0:892	= 6.2202m 0:893	= 653.6131m
+0:894	= 653.6332m 0:895	= 691.5827m 0:896	= 31.3327m
+0:897	= 32.4567m 0:898	= 1.9855 0:899	= 91.2850m
+0:900	= 84.3312m 0:901	= 724.2191m 0:902	= 1.4146
+0:903	= 687.4007m 0:904	= 281.0448m 0:905	= -2.1776
+0:906	= 185.3336m 0:907	= -1.2102 0:908	= 658.5029m
+0:909	= 52.0502m 0:910	= 658.7224m 0:911	= 52.0553m
+0:912	= 653.5485m 0:913	= 653.5488m 0:914	= 32.4441m
+0:915	= 1.3252 0:916	= 185.3336m 0:917	= -464.6010m
+0:918	= -1.8551 0:919	= 62.1464m 0:920	= 1.2617
+0:921	= 654.8023m 0:922	= 94.4918m 0:923	= 720.2099m
+0:924	= 711.4147m 0:925	= 62.4027m 0:926	= 185.3336m
+0:927	= 185.3336m 0:928	= -1.5327 0:929	= 260.0000m
+0:930	= 83.7791m 0:931	= 614.6034m 0:932	= 681.1434m
+0:933	= 81.2916m 0:934	= 61.2124m 0:935	= 658.4953m
+0:936	= 636.6471m 0:937	= 658.7714m 0:938	= 53.0813m
+0:939	= 658.7619m 0:940	= 53.0813m 0:941	= 52.0565m
+0:942	= 658.7527m 0:943	= 1.3587 0:944	= 693.5732m
+0:945	= 6.8662m 0:946	= 63.1800m 0:947	= 64.9795m
+0:948	= 6.2202m 0:949	= 5.2838m 0:950	= 68.5971m
+0:951	= 59.0465m 0:952	= 32.4169m 0:953	= 653.6105m
+0:954	= 653.6331m 0:955	= 32.4564m 0:956	= 1.9855
+0:957	= -464.6010m 0:958	= -1.5327 0:959	= 687.4007m
+0:960	= 1.4146 0:961	= 281.0448m 0:962	= -1.8551
+0:963	= 91.2850m 0:964	= -2.1776 0:965	= 706.7093m
+0:966	= 53.6483m 0:967	= 44.1940m 0:968	= 18.5576m
+0:969	= 51.1112m 0:970	= 650.4577m 0:971	= 650.3010m
+0:972	= 650.5376m 0:973	= 650.4577m 0:974	= 651.5281m
+0:975	= 56.9511m 0:976	= 651.5281m 0:977	= 651.6083m
+0:978	= 26.2368m 0:979	= 1.9864 0:980	= 91.2977m
+0:981	= 52.0122m 0:982	= 1.4151 0:983	= 687.7530m
+0:984	= 281.0546m 0:985	= -2.1776 0:986	= -464.5912m
+0:987	= -1.8551 0:988	= -1.5327 0:989	= 653.6139m
+0:990	= 653.6332m 0:991	= 32.4567m 0:992	= 21.4729m
+0:993	= 21.4729m 0:994	= 1.9855 0:995	= 91.2850m
+0:996	= 1.3562 0:997	= 1.3559 0:998	= 64.9795m
+0:999	= 1.3557 0:1000	= 39.0383m 0:1001	= 691.0004m
+0:1002	= 690.9398m 0:1003	= 6.2202m 0:1004	= 690.8906m
+0:1005	= 30.9656m 0:1006	= 1.4146 0:1007	= 687.4007m
+0:1008	= 281.0448m 0:1009	= -2.1776 0:1010	= -464.6010m
+0:1011	= -1.8551 0:1012	= -1.5327 0:1013	= 653.6130m
+0:1014	= 31.3464m 0:1015	= 653.6332m 0:1016	= 32.4567m
+0:1017	= 1.9855 0:1018	= -464.6010m 0:1019	= -1.5327
+0:1020	= 32.4441m 0:1021	= 653.5488m 0:1022	= 653.5485m
+0:1023	= 52.0553m 0:1024	= 658.7224m 0:1025	= 52.0122m
+0:1026	= 651.3674m 0:1027	= 651.6047m 0:1028	= 651.5245m
+0:1029	= 52.0122m 0:1030	= 56.9511m 0:1031	= 653.5411m

+0:1032 = 653.6218m 0:1033 = 32.4197m 0:1034 = 1.9855
 +0:1035 = -464.6009m 0:1036 = -1.5327 0:1037 = 687.4029m
 +0:1038 = 1.4146 0:1039 = 687.4007m 0:1040 = 1.4146
 +0:1041 = 1.3575 0:1042 = 693.2527m 0:1043 = 58.9939m
 +0:1044 = 1.3568 0:1045 = 691.6966m 0:1046 = 6.2202m
 +0:1047 = 64.9795m 0:1048 = 1.3566 0:1049 = 691.6358m
 +0:1050 = 5.2838m 0:1051 = 68.5971m 0:1052 = 43.7297m
 +0:1053 = 281.0448m 0:1054 = -1.8551 0:1055 = 281.0448m
 +0:1056 = -1.8551 0:1057 = 91.2850m 0:1058 = -2.1776
 +0:1059 = 91.2850m 0:1060 = -2.1776 0:1061 = 1.3336
 +0:1062 = 1.3336 0:1063 = 55.0936m 0:1064 = 55.0936m
 +0:1065 = 55.0936m 0:1066 = 55.0936m 0:1067 = 66.1073m
 +0:1068 = 668.0228m 0:1069 = 616.9350m 0:1070 = 268.2792n
 +0:1071 = 80.8626m 0:1072 = 1.9044 0:1073 = 1.3296
 +0:1074 = 620.9308m 0:1075 = 1.2422 0:1076 = 794.3590m
 +0:1077 = 968.6015m 0:1078 = 604.6550m 0:1079 = 418.2974m
 +0:1080 = 274.2922m 0:1081 = 700.0000m 0:1082 = 400.0000m
 +0:1083 = 1.3336 0:1084 = 1.3336 0:1085 = 55.0936m
 +0:1086 = 55.0936m 0:1087 = 55.0936m 0:1088 = 55.0936m
 +0:1089 = 66.1073m 0:1090 = 668.0228m 0:1091 = 616.9350m
 +0:1092 = 268.2792n 0:1093 = 80.8626m 0:1094 = 1.9044
 +0:1095 = 1.3296 0:1096 = 620.9308m 0:1097 = 1.2422
 +0:1098 = 794.3590m 0:1099 = 968.6015m 0:1100 = 604.6550m
 +0:1101 = 418.2974m 0:1102 = 274.2922m 0:1103 = 400.0000m
 +0:1104 = 1.3336 0:1105 = 1.3336 0:1106 = 55.0936m
 +0:1107 = 55.0936m 0:1108 = 55.0936m 0:1109 = 55.0936m
 +0:1110 = 66.1073m 0:1111 = 668.0228m 0:1112 = 616.9350m
 +0:1113 = 268.2792n 0:1114 = 80.8626m 0:1115 = 1.9044
 +0:1116 = 1.3296 0:1117 = 620.9308m 0:1118 = 1.2422
 +0:1119 = 794.3590m 0:1120 = 968.6015m 0:1121 = 604.6550m
 +0:1122 = 418.2974m 0:1123 = 274.2922m 0:1124 = 400.0000m
 +0:1125 = 62.5383m 0:1126 = 62.5383m 0:1127 = 1.3884
 +0:1128 = 1.3884 0:1129 = 1.3884 0:1130 = 1.3884
 +0:1131 = 609.1270m 0:1132 = 7.1368m 0:1133 = 163.1089m
 +0:1134 = 60.9597m 0:1135 = 795.6718m 0:1136 = 1.2258
 +0:1137 = 741.4580m 0:1138 = 621.2990m 0:1139 = 1.9308
 +0:1140 = 1.3261 0:1141 = 448.5702m 0:1142 = 914.9048m
 +0:1143 = 515.5815m 0:1144 = 606.4125m 0:1145 = 1.1000
 +0:1146 = 62.5383m 0:1147 = 62.5383m 0:1148 = 1.3270
 +0:1149 = 1.3270 0:1150 = 1.3270 0:1151 = 1.3270
 +0:1152 = 609.1270m 0:1153 = 7.1368m 0:1154 = 163.1089m
 +0:1155 = 60.9597m 0:1156 = 795.6718m 0:1157 = 1.2258
 +0:1158 = 741.4580m 0:1159 = 621.2990m 0:1160 = 1.9308
 +0:1161 = 1.3261 0:1162 = 448.5702m 0:1163 = 914.9048m
 +0:1164 = 515.5815m 0:1165 = 606.4125m 0:1166 = 1.1000
 +0:1167 = 62.5383m 0:1168 = 62.5383m 0:1169 = 1.3211
 +0:1170 = 1.3211 0:1171 = 1.3211 0:1172 = 1.3211
 +0:1173 = 609.1270m 0:1174 = 7.1368m 0:1175 = 163.1089m
 +0:1176 = 60.9597m 0:1177 = 795.6718m 0:1178 = 1.2258
 +0:1179 = 741.4580m 0:1180 = 621.2990m 0:1181 = 1.9308
 +0:1182 = 1.3261 0:1183 = 448.5702m 0:1184 = 914.9048m

+0:1185	= 515.5815m	0:1186	= 606.4125m	0:1187	= 1.1000
+0:1188	= 62.5383m	0:1189	= 62.5383m	0:1190	= 1.3715
+0:1191	= 1.3715	0:1192	= 1.3715	0:1193	= 1.3715
+0:1194	= 609.1270m	0:1195	= 7.1368m	0:1196	= 163.1089m
+0:1197	= 60.9597m	0:1198	= 795.6718m	0:1199	= 1.2258
+0:1200	= 741.4580m	0:1201	= 621.2990m	0:1202	= 1.9308
+0:1203	= 1.3261	0:1204	= 448.5702m	0:1205	= 914.9048m
+0:1206	= 515.5815m	0:1207	= 606.4125m	0:1208	= 1.1000
+0:1209	= 62.5383m	0:1210	= 62.5383m	0:1211	= 1.3715
+0:1212	= 1.3715	0:1213	= 1.3715	0:1214	= 1.3715
+0:1215	= 609.1270m	0:1216	= 7.1368m	0:1217	= 163.1089m
+0:1218	= 60.9597m	0:1219	= 795.6718m	0:1220	= 1.2258
+0:1221	= 741.4580m	0:1222	= 621.2990m	0:1223	= 1.9308
+0:1224	= 1.3261	0:1225	= 448.5702m	0:1226	= 914.9048m
+0:1227	= 515.5815m	0:1228	= 606.4125m	0:1229	= 1.1000
+0:1230	= 1.3336	0:1231	= 1.3336	0:1232	= 55.0936m
+0:1233	= 55.0936m	0:1234	= 55.0936m	0:1235	= 55.0936m
+0:1236	= 66.1073m	0:1237	= 668.0228m	0:1238	= 616.9350m
+0:1239	= 268.2792n	0:1240	= 80.8626m	0:1241	= 1.9044
0:1242	= 1.3296	0:1243	= 620.9308m	0:1244	= 1.2422
+0:1245	= 794.3590m	0:1246	= 968.6015m	0:1247	= 604.6550m
+0:1248	= 418.2974m	0:1249	= 274.2922m	0:1250	= 400.0000m
+0:1251	= 62.5383m	0:1252	= 62.5383m	0:1253	= 1.3715
+0:1254	= 1.3715	0:1255	= 1.3715	0:1256	= 1.3715
+0:1257	= 609.1270m	0:1258	= 7.1368m	0:1259	= 163.1089m
+0:1260	= 60.9597m	0:1261	= 795.6718m	0:1262	= 1.2258
+0:1263	= 741.4580m	0:1264	= 621.2990m	0:1265	= 1.9308
+0:1266	= 1.3261	0:1267	= 448.5702m	0:1268	= 914.9048m
+0:1269	= 515.5815m	0:1270	= 606.4125m	0:1271	= 1.1000
+0:1272	= 62.5383m	0:1273	= 62.5383m	0:1274	= 1.3305
+0:1275	= 1.3305	0:1276	= 1.3305	0:1277	= 1.3305
+0:1278	= 609.1270m	0:1279	= 7.1368m	0:1280	= 163.1089m
+0:1281	= 60.9597m	0:1282	= 795.6718m	0:1283	= 1.2258
+0:1284	= 741.4580m	0:1285	= 621.2990m	0:1286	= 1.9308
+0:1287	= 1.3261	0:1288	= 448.5702m	0:1289	= 914.9048m
+0:1290	= 515.5815m	0:1291	= 606.4125m	0:1292	= 1.1000
+0:1293	= 1.3336	0:1294	= 1.3336	0:1295	= 55.0936m
+0:1296	= 55.0936m	0:1297	= 55.0936m	0:1298	= 55.0936m
+0:1299	= 66.1073m	0:1300	= 668.0228m	0:1301	= 616.9350m
+0:1302	= 268.2792n	0:1303	= 80.8626m	0:1304	= 1.9044
+0:1305	= 1.3296	0:1306	= 620.9308m	0:1307	= 1.2422
+0:1308	= 794.3590m	0:1309	= 968.6015m	0:1310	= 604.6550m
+0:1311	= 418.2974m	0:1312	= 274.2922m	0:1313	= 400.0000m

maximum nodal capacitance= 4.291E-11 on node 0:1

nodal capacitance table

node = cap node = cap node = cap

+0:1	= 42.9105p 0:100	= 325.7088f 0:101	= 197.9760f
+0:102	= 170.9088f 0:103	= 123.8339f 0:104	= 2.5773p
+0:105	= 2.2431p 0:106	= 1.2935p 0:107	= 2.3619p
+0:108	= 325.7088f 0:109	= 193.9920f 0:110	= 170.9088f
+0:111	= 123.8339f 0:112	= 2.5773p 0:113	= 2.2431p
+0:114	= 1.2935p 0:115	= 2.3619p 0:116	= 325.7088f
+0:117	= 554.8905f 0:118	= . 9088f 0:119	= 123.8339f
+0:120	= 2.5773p 0:121	= 2.2431p 0:122	= 1.2935p
+0:123	= 2.3619p 0:124	= 325.7088f 0:125	= 554.8905f
+0:126	= 170.9088f 0:127	= 123.8339f 0:128	= 2.5773p
+0:129	= 2.2431p 0:130	= 1.2935p 0:131	= 2.3619p
+0:132	= 325.7088f 0:133	= 554.8905f 0:134	= 170.9088f
+0:135	= 123.8339f 0:136	= 2.5773p 0:137	= 2.2431p
+0:138	= 1.2935p 0:139	= 2.3619p 0:140	= 325.7088f
+0:141	= 554.8905f 0:142	= 170.9088f 0:143	= 123.8339f
+0:144	= 2.5773p 0:145	= 2.2431p 0:146	= 1.2935p
+0:147	= 2.3619p 0:148	= 227.3520f 0:149	= 223.3680f
+0:150	= 227.3520f 0:151	= 223.3680f 0:152	= 434.7120f
+0:153	= 227.3520f 0:154	= 223.3680f 0:155	= 227.3520f
+0:156	= 223.3680f 0:157	= 434.7120f 0:158	= 227.3520f
+0:159	= 223.3680f 0:160	= 227.3520f 0:161	= 223.3680f
+0:162	= 434.7120f 0:163	= 227.3520f 0:164	= 223.3680f
+0:165	= 227.3520f 0:166	= 223.3680f 0:167	= 434.7120f
+0:168	= 1.2737p 0:169	= 3.1795p 0:170	= 223.3680f
+0:171	= 365.5920f 0:172	= 361.6080f 0:173	= 227.3520f
+0:174	= 1.2803p 0:175	= 3.1795p 0:176	= 17.1008f
+0:177	= 360.7840f 0:178	= 79.6064f 0:179	= 139.9840f
+0:180	= 630.6560f 0:181	= 625.3440f 0:182	= 139.9840f
+0:183	= 139.9840f 0:184	= 447.9840f 0:185	= 32.0640f
+0:186	= 625.3440f 0:187	= 139.9840f 0:188	= 139.9840f
+0:189	= 630.6560f 0:190	= 301.1280f 0:191	= 223.1840f
+0:192	= 305.1120f 0:193	= 625.3440f 0:194	= 139.9840f
+0:195	= 447.9840f 0:196	= 434.7120f 0:197	= 499.8480f
+0:198	= 296.4720f 0:199	= 223.3680f 0:200	= 227.3520f
+0:201	= 223.3680f 0:202	= 1.1910p 0:203	= 711.1920f
+0:204	= 361.6080f 0:205	= 139.9840f 0:206	= 630.6560f
+0:207	= 276.4800f 0:208	= 415.4294f 0:209	= 276.4800f
+0:210	= 446.0266f 0:211	= 276.4800f 0:212	= 415.4294f
+0:213	= 276.4800f 0:214	= 139.9840f 0:215	= 630.6560f
+0:216	= 625.3440f 0:217	= 139.9840f 0:218	= 79.6064f
+0:219	= 139.9840f 0:220	= 419.4134f 0:221	= 726.4905f
+0:222	= 419.4134f 0:223	= 726.4905f 0:224	= 361.6080f
+0:225	= 691.2000f 0:226	= 276.4800f 0:227	= 2.4883p
+0:228	= 276.4800f 0:229	= 276.4800f 0:230	= 276.4800f
+0:231	= 227.3520f 0:232	= 223.3680f 0:233	= 227.3520f
+0:234	= 223.3680f 0:235	= 227.3520f 0:236	= 223.3680f
+0:237	= 227.3520f 0:238	= 223.3680f 0:239	= 434.7120f
+0:240	= 113.9280f 0:241	= 61.8576f 0:242	= 361.6080f

+0:243	=	6.8256p 0:244	=	2.6466p 0:245	=	17.6192f
+0:246	=	35.4816f 0:247	=	53.3600f 0:248	=	1.7123p
+0:249	=	40.0000f 0:250	=	80.0000f 0:251	=	40.0000f
+0:252	=	40.0000f 0:253	=	2.2118p 0:254	=	227.3520f
+0:255	=	223.3680f 0:256	=	227.3520f 0:257	=	223.3680f
+0:258	=	227.3520f 0:259	=	223.3680f 0:260	=	227.3520f
+0:261	=	223.3680f 0:262	=	430.7280f 0:263	=	113.9280f
+0:264	=	80.0000f 0:265	=	40.0000f 0:266	=	42.9184f
+0:267	=	17.6192f 0:268	=	53.3600f 0:269	=	40.0000f
+0:270	=	61.8576f 0:271	=	40.0000f 0:272	=	227.3520f
+0:273	=	223.3680f 0:274	=	227.3520f 0:275	=	223.3680f
+0:276	=	434.7120f 0:277	=	227.3520f 0:278	=	223.3680f
+0:279	=	227.3520f 0:280	=	223.3680f 0:281	=	434.7120f
+0:282	=	227.3520f 0:283	=	223.3680f 0:284	=	227.3520f
+0:285	=	223.3680f 0:286	=	434.7120f 0:287	=	227.3520f
+0:288	=	223.3680f 0:289	=	227.3520f 0:290	=	223.3680f
+0:291	=	434.7120f 0:292	=	1.8188p 0:293	=	1.8188p
+0:294	=	1.8188p 0:295	=	358.9744f 0:296	=	1.5264p
+0:297	=	3.6461p 0:298	=	2.4490p 0:299	=	5.5296p
+0:300	=	1.8188p 0:301	=	790.5920f 0:302	=	881.2800f
+0:303	=	358.9744f 0:304	=	2.4490p 0:305	=	5.5296p
+0:306	=	1.2737p 0:307	=	223.3680f 0:308	=	365.5920f
+0:309	=	361.6080f 0:310	=	227.3520f 0:311	=	1.2803p
+0:312	=	79.6064f 0:313	=	630.6560f 0:314	=	625.3440f
+0:315	=	447.9840f 0:316	=	625.3440f 0:317	=	630.6560f
+0:318	=	301.1280f 0:319	=	1.7869p 0:320	=	891.9200f
+0:321	=	891.9200f 0:322	=	1.1292p 0:323	=	1.1292p
+0:324	=	609.5920f 0:325	=	622.0800f 0:326	=	113.9280f
+0:327	=	80.0000f 0:328	=	1.7869p 0:329	=	305.1120f
+0:330	=	113.9280f 0:331	=	61.8576f 0:332	=	40.0000f
+0:333	=	17.6192f 0:334	=	35.4816f 0:335	=	53.3600f
+0:336	=	40.0000f 0:337	=	625.3440f 0:338	=	447.9840f
+0:339	=	434.7120f 0:340	=	499.8480f 0:341	=	296.4720f
+0:342	=	223.3680f 0:343	=	227.3520f 0:344	=	223.3680f
+0:345	=	711.1920f 0:346	=	361.6080f 0:347	=	630.6560f
+0:348	=	80.0000f 0:349	=	40.0000f 0:350	=	276.4800f
+0:351	=	415.4294f 0:352	=	276.4800f 0:353	=	446.0266f
+0:354	=	276.4800f 0:355	=	415.4294f 0:356	=	276.4800f
+0:357	=	40.0000f 0:358	=	630.6560f 0:359	=	625.3440f
+0:360	=	79.6064f 0:361	=	419.4134f 0:362	=	726.4905f
+0:363	=	419.4134f 0:364	=	726.4905f 0:365	=	361.6080f
+0:366	=	42.9184f 0:367	=	17.6192f 0:368	=	53.3600f
+0:369	=	40.0000f 0:370	=	61.8576f 0:371	=	40.0000f
+0:372	=	691.2000f 0:373	=	276.4800f 0:374	=	276.4800f
+0:375	=	276.4800f 0:376	=	276.4800f 0:377	=	227.3520f
+0:378	=	223.3680f 0:379	=	227.3520f 0:380	=	223.3680f
+0:381	=	227.3520f 0:382	=	223.3680f 0:383	=	227.3520f
+0:384	=	223.3680f 0:385	=	434.7120f 0:386	=	113.9280f
+0:387	=	61.8576f 0:388	=	361.6080f 0:389	=	17.6192f
+0:390	=	35.4816f 0:391	=	53.3600f 0:392	=	40.0000f
+0:393	=	80.0000f 0:394	=	40.0000f 0:395	=	40.0000f

+0:396	= 227.3520f 0:397	= 223.3680f 0:398	= 227.3520f
+0:399	= 223.3680f 0:400	= 227.3520f 0:401	= 223.3680f
+0:402	= 227.3520f 0:403	= 223.3680f 0:404	= 430.7280f
+0:405	= 113.9280f 0:406	= 80.0000f 0:407	= 40.0000f
+0:408	= 42.9184f 0:409	= 17.6192f 0:410	= 53.3600f
+0:411	= 40.0000f 0:412	= 61.8576f 0:413	= 40.0000f
+0:414	= 227.3520f 0:415	= 223.3680f 0:416	= 227.3520f
+0:417	= 223.3680f 0:418	= 434.7120f 0:419	= 227.3520f
+0:420	= 223.3680f 0:421	= 227.3520f 0:422	= 223.3680f
+0:423	= 434.7120f 0:424	= 227.3520f 0:425	= 223.3680f
+0:426	= 227.3520f 0:427	= 223.3680f 0:428	= 434.7120f
+0:429	= 227.3520f 0:430	= 223.3680f 0:431	= 227.3520f
+0:432	= 223.3680f 0:433	= 434.7120f 0:434	= 227.3520f
+0:435	= 448.4685f 0:436	= 125.8163f 0:437	= 125.8163f
+0:438	= 100.7437f 0:439	= 1.0528p 0:440	= 483.8400f
+0:441	= 1.4515p 0:442	= 483.8400f 0:443	= 113.9280f
+0:444	= 61.8576f 0:445	= 483.8400f 0:446	= 17.6192f
+0:447	= 35.4816f 0:448	= 53.3600f 0:449	= 40.0000f
+0:450	= 1.2737p 0:451	= 223.3680f 0:452	= 365.5920f
+0:453	= 361.6080f 0:454	= 227.3520f 0:455	= 1.2803p
+0:456	= 80.0000f 0:457	= 40.0000f 0:458	= 40.0000f
+0:459	= 79.6064f 0:460	= 630.6560f 0:461	= 625.3440f
+0:462	= 447.9840f 0:463	= 625.3440f 0:464	= 630.6560f
+0:465	= 223.3680f 0:466	= 414.7200f 0:467	= 499.8480f
+0:468	= 125.8163f 0:469	= 207.3600f 0:470	= 207.3600f
+0:471	= 100.7437f 0:472	= 776.3280f 0:473	= 638.0880f
+0:474	= 125.8163f 0:475	= 207.3600f 0:476	= 207.3600f
+0:477	= 100.7437f 0:478	= 215.8976f 0:479	= 299.5661f
+0:480	= 125.8163f 0:481	= 2.2810p 0:482	= 301.1280f
+0:483	= 305.1120f 0:484	= 227.3520f 0:485	= 223.3680f
+0:486	= 296.4720f 0:487	= 227.3520f 0:488	= 223.3680f
+0:489	= 296.4720f 0:490	= 296.4720f 0:491	= 223.3680f
+0:492	= 223.3680f 0:493	= 223.3680f 0:494	= 223.3680f
+0:495	= 365.5920f 0:496	= 361.6080f 0:497	= 223.3680f
+0:498	= 223.3680f 0:499	= 223.3680f 0:500	= 365.5920f
+0:501	= 499.8480f 0:502	= 223.3680f 0:503	= 223.3680f
+0:504	= 296.4720f 0:505	= 223.3680f 0:506	= 625.3440f
+0:507	= 447.9840f 0:508	= 419.4134f 0:509	= 864.7305f
+0:510	= 419.4134f 0:511	= 450.0106f 0:512	= 914.5680f
+0:513	= 503.8320f 0:514	= 361.6080f 0:515	= 434.7120f
+0:516	= 499.8480f 0:517	= 296.4720f 0:518	= 223.3680f
+0:519	= 227.3520f 0:520	= 223.3680f 0:521	= 711.1920f
+0:522	= 361.6080f 0:523	= 630.6560f 0:524	= 776.3280f
+0:525	= 361.6080f 0:526	= 276.4800f 0:527	= 276.4800f
+0:528	= 276.4800f 0:529	= 276.4800f 0:530	= 276.4800f
+0:531	= 415.4294f 0:532	= 276.4800f 0:533	= 446.0266f
+0:534	= 276.4800f 0:535	= 415.4294f 0:536	= 276.4800f
+0:537	= 125.8163f 0:538	= 483.8400f 0:539	= 125.8163f
+0:540	= 483.8400f 0:541	= 483.8400f 0:542	= 100.7437f
+0:543	= 446.3437f 0:544	= 113.9280f 0:545	= 630.6560f
+0:546	= 625.3440f 0:547	= 80.0000f 0:548	= 79.6064f

+0:549	= 419.4134f 0:550	= 726.4905f 0:551	= 40.0000f
+0:552	= 419.4134f 0:553	= 726.4905f 0:554	= 42.9184f
+0:555	= 17.6192f 0:556	= 53.3600f 0:557	= 361.6080f
+0:558	= 40.0000f 0:559	= 61.8576f 0:560	= 40.0000f
+0:561	= 642.0720f 0:562	= 638.0880f 0:563	= 638.0880f
+0:564	= 125.8163f 0:565	= 100.7437f 0:566	= 125.8163f
+0:567	= 100.7437f 0:568	= 218.0224f 0:569	= 281.1734f
+0:570	= 125.8163f 0:571	= 100.7437f 0:572	= 148.9024f
+0:573	= 223.3680f 0:574	= 223.3680f 0:575	= 223.3680f
+0:576	= 361.6080f 0:577	= 223.3680f 0:578	= 223.3680f
+0:579	= 223.3680f 0:580	= 361.6080f 0:581	= 223.3680f
+0:582	= 223.3680f 0:583	= 292.4880f 0:584	= 638.0880f
+0:585	= 361.6080f 0:586	= 227.3520f 0:587	= 223.3680f
+0:588	= 296.4720f 0:589	= 227.3520f 0:590	= 223.3680f
+0:591	= 158.2320f 0:592	= 276.4800f 0:593	= 207.3600f
+0:594	= 207.3600f 0:595	= 622.0800f 0:596	= 125.8163f
+0:597	= 230.4461f 0:598	= 1.0368p 0:599	= 776.3280f
+0:600	= 776.3280f 0:601	= 207.3600f 0:602	= 207.3600f
+0:603	= 207.3600f 0:604	= 691.2000f 0:605	= 276.4800f
+0:606	= 276.4800f 0:607	= 276.4800f 0:608	= 276.4800f
+0:609	= 227.3520f 0:610	= 223.3680f 0:611	= 227.3520f
+0:612	= 223.3680f 0:613	= 227.3520f 0:614	= 223.3680f
+0:615	= 227.3520f 0:616	= 223.3680f 0:617	= 434.7120f
+0:618	= 113.9280f 0:619	= 61.8576f 0:620	= 361.6080f
+0:621	= 17.6192f 0:622	= 35.4816f 0:623	= 53.3600f
+0:624	= 40.0000f 0:625	= 80.0000f 0:626	= 40.0000f
+0:627	= 40.0000f 0:628	= 207.3600f 0:629	= 299.5661f
+0:630	= 227.3520f 0:631	= 223.3680f 0:632	= 296.4720f
+0:633	= 113.9280f 0:634	= 61.8576f 0:635	= 365.5920f
+0:636	= 223.3680f 0:637	= 223.3680f 0:638	= 223.3680f
+0:639	= 223.3680f 0:640	= 365.5920f 0:641	= 361.6080f
+0:642	= 223.3680f 0:643	= 223.3680f 0:644	= 223.3680f
+0:645	= 365.5920f 0:646	= 499.8480f 0:647	= 223.3680f
+0:648	= 223.3680f 0:649	= 296.4720f 0:650	= 223.3680f
+0:651	= 914.5680f 0:652	= 138.2400f 0:653	= 361.6080f
+0:654	= 361.6080f 0:655	= 100.7437f 0:656	= 253.3939f
+0:657	= 207.3600f 0:658	= 207.3600f 0:659	= 146.7776f
+0:660	= 125.8163f 0:661	= 100.7437f 0:662	= 307.7866f
+0:663	= 276.4800f 0:664	= 125.8163f 0:665	= 207.3600f
+0:666	= 207.3600f 0:667	= 100.7437f 0:668	= 125.8163f
+0:669	= 207.3600f 0:670	= 207.3600f 0:671	= 100.7437f
+0:672	= 215.8976f 0:673	= 299.5661f 0:674	= 17.6192f
+0:675	= 35.4816f 0:676	= 53.3600f 0:677	= 40.0000f
+0:678	= 80.0000f 0:679	= 40.0000f 0:680	= 40.0000f
+0:681	= 125.8163f 0:682	= 100.7437f 0:683	= 125.8163f
+0:684	= 100.7437f 0:685	= 218.0224f 0:686	= 227.3520f
+0:687	= 223.3680f 0:688	= 296.4720f 0:689	= 113.9280f
+0:690	= 80.0000f 0:691	= 40.0000f 0:692	= 227.3520f
+0:693	= 223.3680f 0:694	= 227.3520f 0:695	= 223.3680f
+0:696	= 227.3520f 0:697	= 223.3680f 0:698	= 227.3520f
+0:699	= 223.3680f 0:700	= 430.7280f 0:701	= 113.9280f

+0:702	= 80.0000f 0:703	= 40.0000f 0:704	= 42.9184f
+0:705	= 17.6192f 0:706	= 42.9184f 0:707	= 17.6192f
+0:708	= 227.3520f 0:709	= 227.3520f 0:710	= 223.3680f
+0:711	= 296.4720f 0:712	= 227.3520f 0:713	= 223.3680f
+0:714	= 296.4720f 0:715	= 227.3520f 0:716	= 223.3680f
+0:717	= 223.3680f 0:718	= 361.6080f 0:719	= 365.5920f
+0:720	= 227.3520f 0:721	= 223.3680f 0:722	= 223.3680f
+0:723	= 223.3680f 0:724	= 223.3680f 0:725	= 223.3680f
+0:726	= 361.6080f 0:727	= 223.3680f 0:728	= 223.3680f
+0:729	= 223.3680f 0:730	= 361.6080f 0:731	= 223.3680f
+0:732	= 223.3680f 0:733	= 292.4880f 0:734	= 138.2400f
+0:735	= 207.3600f 0:736	= 207.3600f 0:737	= 207.3600f
+0:738	= 207.3600f 0:739	= 299.5661f 0:740	= 53.3600f
+0:741	= 53.3600f 0:742	= 40.0000f 0:743	= 61.8576f
+0:744	= 40.0000f 0:745	= 40.0000f 0:746	= 227.3520f
+0:747	= 223.3680f 0:748	= 227.3520f 0:749	= 223.3680f
+0:750	= 61.8576f 0:751	= 40.0000f 0:752	= 434.7120f
+0:753	= 227.3520f 0:754	= 223.3680f 0:755	= 227.3520f
+0:756	= 223.3680f 0:757	= 434.7120f 0:758	= 227.3520f
+0:759	= 223.3680f 0:760	= 227.3520f 0:761	= 223.3680f
+0:762	= 434.7120f 0:763	= 227.3520f 0:764	= 223.3680f
+0:765	= 227.3520f 0:766	= 223.3680f 0:767	= 434.7120f
+0:768	= 227.3520f 0:769	= 223.3680f 0:770	= 296.4720f
+0:771	= 113.9280f 0:772	= 61.8576f 0:773	= 17.6192f
+0:774	= 35.4816f 0:775	= 53.3600f 0:776	= 40.0000f
+0:777	= 80.0000f 0:778	= 40.0000f 0:779	= 1.2737p
+0:780	= 223.3680f 0:781	= 365.5920f 0:782	= 361.6080f
+0:783	= 227.3520f 0:784	= 1.2803p 0:785	= 40.0000f
+0:786	= 79.6064f 0:787	= 630.6560f 0:788	= 625.3440f
+0:789	= 447.9840f 0:790	= 625.3440f 0:791	= 227.3520f
+0:792	= 223.3680f 0:793	= 296.4720f 0:794	= 227.3520f
+0:795	= 223.3680f 0:796	= 296.4720f 0:797	= 227.3520f
+0:798	= 223.3680f 0:799	= 296.4720f 0:800	= 434.7120f
+0:801	= 223.3680f 0:802	= 223.3680f 0:803	= 223.3680f
+0:804	= 223.3680f 0:805	= 365.5920f 0:806	= 361.6080f
+0:807	= 223.3680f 0:808	= 223.3680f 0:809	= 223.3680f
+0:810	= 365.5920f 0:811	= 499.8480f 0:812	= 223.3680f
+0:813	= 223.3680f 0:814	= 296.4720f 0:815	= 223.3680f
+0:816	= 914.5680f 0:817	= 430.7280f 0:818	= 361.6080f
+0:819	= 223.3680f 0:820	= 138.2400f 0:821	= 227.3520f
+0:822	= 552.9600f 0:823	= 223.3680f 0:824	= 296.4720f
+0:825	= 227.3520f 0:826	= 223.3680f 0:827	= 296.4720f
+0:828	= 227.3520f 0:829	= 223.3680f 0:830	= 223.3680f
+0:831	= 361.6080f 0:832	= 365.5920f 0:833	= 125.8163f
+0:834	= 207.3600f 0:835	= 207.3600f 0:836	= 100.7437f
+0:837	= 125.8163f 0:838	= 207.3600f 0:839	= 207.3600f
+0:840	= 100.7437f 0:841	= 215.8976f 0:842	= 299.5661f
+0:843	= 227.3520f 0:844	= 223.3680f 0:845	= 296.4720f
+0:846	= 113.9280f 0:847	= 80.0000f 0:848	= 40.0000f
+0:849	= 630.6560f 0:850	= 42.9184f 0:851	= 17.6192f
+0:852	= 53.3600f 0:853	= 301.1280f 0:854	= 40.0000f

+0:855	= 61.8576f 0:856	= 40.0000f 0:857	= 305.1120f
+0:858	= 125.8163f 0:859	= 100.7437f 0:860	= 125.8163f
+0:861	= 100.7437f 0:862	= 218.0224f 0:863	= 227.3520f
+0:864	= 227.3520f 0:865	= 223.3680f 0:866	= 296.4720f
+0:867	= 227.3520f 0:868	= 223.3680f 0:869	= 296.4720f
+0:870	= 227.3520f 0:871	= 223.3680f 0:872	= 227.3520f
+0:873	= 223.3680f 0:874	= 223.3680f 0:875	= 223.3680f
+0:876	= 223.3680f 0:877	= 361.6080f 0:878	= 223.3680f
+0:879	= 223.3680f 0:880	= 223.3680f 0:881	= 361.6080f
+0:882	= 223.3680f 0:883	= 223.3680f 0:884	= 292.4880f
+0:885	= 227.3520f 0:886	= 223.3680f 0:887	= 223.3680f
+0:888	= 361.6080f 0:889	= 365.5920f 0:890	= 207.3600f
+0:891	= 207.3600f 0:892	= 207.3600f 0:893	= 227.3520f
+0:894	= 223.3680f 0:895	= 207.3600f 0:896	= 299.5661f
+0:897	= 296.4720f 0:898	= 113.9280f 0:899	= 61.8576f
+0:900	= 138.2400f 0:901	= 552.9600f 0:902	= 17.6192f
+0:903	= 35.4816f 0:904	= 53.3600f 0:905	= 40.0000f
+0:906	= 625.3440f 0:907	= 447.9840f 0:908	= 434.7120f
+0:909	= 499.8480f 0:910	= 296.4720f 0:911	= 223.3680f
+0:912	= 227.3520f 0:913	= 223.3680f 0:914	= 711.1920f
+0:915	= 361.6080f 0:916	= 630.6560f 0:917	= 80.0000f
+0:918	= 40.0000f 0:919	= 276.4800f 0:920	= 415.4294f
+0:921	= 276.4800f 0:922	= 446.0266f 0:923	= 276.4800f
+0:924	= 415.4294f 0:925	= 276.4800f 0:926	= 630.6560f
+0:927	= 625.3440f 0:928	= 40.0000f 0:929	= 79.6064f
+0:930	= 419.4134f 0:931	= 726.4905f 0:932	= 419.4134f
+0:933	= 726.4905f 0:934	= 361.6080f 0:935	= 365.5920f
+0:936	= 365.5920f 0:937	= 223.3680f 0:938	= 227.3520f
+0:939	= 223.3680f 0:940	= 227.3520f 0:941	= 223.3680f
+0:942	= 223.3680f 0:943	= 125.8163f 0:944	= 207.3600f
+0:945	= 207.3600f 0:946	= 100.7437f 0:947	= 125.8163f
+0:948	= 207.3600f 0:949	= 207.3600f 0:950	= 100.7437f
+0:951	= 215.8976f 0:952	= 299.5661f 0:953	= 227.3520f
+0:954	= 223.3680f 0:955	= 296.4720f 0:956	= 113.9280f
+0:957	= 80.0000f 0:958	= 40.0000f 0:959	= 42.9184f
+0:960	= 17.6192f 0:961	= 53.3600f 0:962	= 40.0000f
+0:963	= 61.8576f 0:964	= 40.0000f 0:965	= 691.2000f
+0:966	= 276.4800f 0:967	= 276.4800f 0:968	= 276.4800f
+0:969	= 276.4800f 0:970	= 227.3520f 0:971	= 223.3680f
+0:972	= 227.3520f 0:973	= 223.3680f 0:974	= 227.3520f
+0:975	= 223.3680f 0:976	= 227.3520f 0:977	= 223.3680f
+0:978	= 434.7120f 0:979	= 113.9280f 0:980	= 61.8576f
+0:981	= 361.6080f 0:982	= 17.6192f 0:983	= 35.4816f
+0:984	= 53.3600f 0:985	= 40.0000f 0:986	= 80.0000f
+0:987	= 40.0000f 0:988	= 40.0000f 0:989	= 227.3520f
+0:990	= 223.3680f 0:991	= 296.4720f 0:992	= 552.9600f
+0:993	= 414.7200f 0:994	= 113.9280f 0:995	= 61.8576f
+0:996	= 125.8163f 0:997	= 100.7437f 0:998	= 125.8163f
+0:999	= 100.7437f 0:1000	= 218.0224f 0:1001	= 207.3600f
+0:1002	= 207.3600f 0:1003	= 207.3600f 0:1004	= 207.3600f
+0:1005	= 299.5661f 0:1006	= 17.6192f 0:1007	= 35.4816f

+0:1008	= 53.3600f 0:1009	= 40.0000f 0:1010	= 80.0000f
+0:1011	= 40.0000f 0:1012	= 40.0000f 0:1013	= 227.3520f
+0:1014	= 299.5661f 0:1015	= 223.3680f 0:1016	= 296.4720f
+0:1017	= 113.9280f 0:1018	= 80.0000f 0:1019	= 40.0000f
+0:1020	= 292.4880f 0:1021	= 227.3520f 0:1022	= 223.3680f
+0:1023	= 227.3520f 0:1024	= 292.4880f 0:1025	= 227.3520f
+0:1026	= 223.3680f 0:1027	= 227.3520f 0:1028	= 223.3680f
+0:1029	= 227.3520f 0:1030	= 223.3680f 0:1031	= 227.3520f
+0:1032	= 223.3680f 0:1033	= 430.7280f 0:1034	= 113.9280f
+0:1035	= 80.0000f 0:1036	= 40.0000f 0:1037	= 42.9184f
+0:1038	= 17.6192f 0:1039	= 42.9184f 0:1040	= 17.6192f
+0:1041	= 169.8637f 0:1042	= 276.4800f 0:1043	= 125.8163f
+0:1044	= 125.8163f 0:1045	= 207.3600f 0:1046	= 207.3600f
+0:1047	= 100.7437f 0:1048	= 125.8163f 0:1049	= 207.3600f
+0:1050	= 207.3600f 0:1051	= 100.7437f 0:1052	= 215.8976f
+0:1053	= 53.3600f 0:1054	= 40.0000f 0:1055	= 53.3600f
+0:1056	= 40.0000f 0:1057	= 61.8576f 0:1058	= 40.0000f
+0:1059	= 61.8576f 0:1060	= 40.0000f 0:1061	= 125.8163f
+0:1062	= 100.7437f 0:1063	= 125.8163f 0:1064	= 100.7437f
+0:1065	= 125.8163f 0:1066	= 100.7437f 0:1067	= 344.9631f
+0:1068	= 691.2000f 0:1069	= 99.7560f 0:1070	= 23.2136f
+0:1071	= 61.8936f 0:1072	= 218.3280f 0:1073	= 33.5880f
+0:1074	= 345.6000f 0:1075	= 218.3280f 0:1076	= 35.1888f
+0:1077	= 21.6000f 0:1078	= 24.0000f 0:1079	= 75.2112f
+0:1080	= 384.1056f 0:1081	= 3.8880p 0:1082	= 1.4944p
+0:1083	= 125.8163f 0:1084	= 100.7437f 0:1085	= 125.8163f
+0:1086	= 100.7437f 0:1087	= 125.8163f 0:1088	= 100.7437f
+0:1089	= 344.9631f 0:1090	= 691.2000f 0:1091	= 99.7560f
+0:1092	= 23.2136f 0:1093	= 61.8936f 0:1094	= 218.3280f
+0:1095	= 33.5880f 0:1096	= 345.6000f 0:1097	= 218.3280f
+0:1098	= 35.1888f 0:1099	= 21.6000f 0:1100	= 24.0000f
+0:1101	= 75.2112f 0:1102	= 384.1056f 0:1103	= 1.4944p
+0:1104	= 125.8163f 0:1105	= 100.7437f 0:1106	= 125.8163f
+0:1107	= 100.7437f 0:1108	= 125.8163f 0:1109	= 100.7437f
+0:1110	= 344.9631f 0:1111	= 691.2000f 0:1112	= 99.7560f
+0:1113	= 23.2136f 0:1114	= 61.8936f 0:1115	= 218.3280f
+0:1116	= 33.5880f 0:1117	= 345.6000f 0:1118	= 218.3280f
+0:1119	= 35.1888f 0:1120	= 21.6000f 0:1121	= 24.0000f
+0:1122	= 75.2112f 0:1123	= 384.1056f 0:1124	= 1.4944p
+0:1125	= 125.8163f 0:1126	= 100.7437f 0:1127	= 125.8163f
+0:1128	= 100.7437f 0:1129	= 125.8163f 0:1130	= 100.7437f
+0:1131	= 344.9631f 0:1132	= 691.2000f 0:1133	= 99.7560f
+0:1134	= 23.2136f 0:1135	= 61.8936f 0:1136	= 218.3280f
+0:1137	= 33.5880f 0:1138	= 345.6000f 0:1139	= 218.3280f
+0:1140	= 35.1888f 0:1141	= 21.6000f 0:1142	= 24.0000f
+0:1143	= 75.2112f 0:1144	= 384.1056f 0:1145	= 1.4944p
+0:1146	= 125.8163f 0:1147	= 100.7437f 0:1148	= 125.8163f
+0:1149	= 100.7437f 0:1150	= 125.8163f 0:1151	= 100.7437f
+0:1152	= 344.9631f 0:1153	= 691.2000f 0:1154	= 99.7560f
+0:1155	= 23.2136f 0:1156	= 61.8936f 0:1157	= 218.3280f
+0:1158	= 33.5880f 0:1159	= 345.6000f 0:1160	= 218.3280f

+0:1161	= 35.1888f 0:1162	= 21.6000f 0:1163	= 24.0000f
+0:1164	= 75.2112f 0:1165	= 384.1056f 0:1166	= 1.4944p
+0:1167	= 125.8163f 0:1168	= 100.7437f 0:1169	= 125.8163f
+0:1170	= 100.7437f 0:1171	= 125.8163f 0:1172	= 100.7437f
+0:1173	= 344.9631f 0:1174	= 691.2000f 0:1175	= 99.7560f
+0:1176	= 23.2136f 0:1177	= 61.8936f 0:1178	= 218.3280f
+0:1179	= 33.5880f 0:1180	= 345.6000f 0:1181	= 218.3280f
+0:1182	= 35.1888f 0:1183	= 21.6000f 0:1184	= 24.0000f
+0:1185	= 75.2112f 0:1186	= 384.1056f 0:1187	= 1.4944p
+0:1188	= 125.8163f 0:1189	= 100.7437f 0:1190	= 125.8163f
+0:1191	= 100.7437f 0:1192	= 125.8163f 0:1193	= 100.7437f
+0:1194	= 344.9631f 0:1195	= 691.2000f 0:1196	= 99.7560f
+0:1197	= 23.2136f 0:1198	= 61.8936f 0:1199	= 218.3280f
+0:1200	= 33.5880f 0:1201	= 345.6000f 0:1202	= 218.3280f
+0:1203	= 35.1888f 0:1204	= 21.6000f 0:1205	= 24.0000f
+0:1206	= 75.2112f 0:1207	= 384.1056f 0:1208	= 1.4944p
+0:1209	= 125.8163f 0:1210	= 100.7437f 0:1211	= 125.8163f
+0:1212	= 100.7437f 0:1213	= 125.8163f 0:1214	= 100.7437f
+0:1215	= 344.9631f 0:1216	= 691.2000f 0:1217	= 99.7560f
+0:1218	= 23.2136f 0:1219	= 61.8936f 0:1220	= 218.3280f
+0:1221	= 33.5880f 0:1222	= 345.6000f 0:1223	= 218.3280f
+0:1224	= 35.1888f 0:1225	= 21.6000f 0:1226	= 24.0000f
+0:1227	= 75.2112f 0:1228	= 384.1056f 0:1229	= 1.4944p
+0:1230	= 125.8163f 0:1231	= 100.7437f 0:1232	= 125.8163f
+0:1233	= 100.7437f 0:1234	= 125.8163f 0:1235	= 100.7437f
+0:1236	= 344.9631f 0:1237	= 691.2000f 0:1238	= 99.7560f
+0:1239	= 23.2136f 0:1240	= 61.8936f 0:1241	= 218.3280f
+0:1242	= 33.5880f 0:1243	= 345.6000f 0:1244	= 218.3280f
+0:1245	= 35.1888f 0:1246	= 21.6000f 0:1247	= 24.0000f
+0:1248	= 75.2112f 0:1249	= 384.1056f 0:1250	= 1.4944p
+0:1251	= 125.8163f 0:1252	= 100.7437f 0:1253	= 125.8163f
+0:1254	= 100.7437f 0:1255	= 125.8163f 0:1256	= 100.7437f
+0:1257	= 344.9631f 0:1258	= 691.2000f 0:1259	= 99.7560f
+0:1260	= 23.2136f 0:1261	= 61.8936f 0:1262	= 218.3280f
+0:1263	= 33.5880f 0:1264	= 345.6000f 0:1265	= 218.3280f
+0:1266	= 35.1888f 0:1267	= 21.6000f 0:1268	= 24.0000f
+0:1269	= 75.2112f 0:1270	= 384.1056f 0:1271	= 1.4944p
+0:1272	= 125.8163f 0:1273	= 100.7437f 0:1274	= 125.8163f
+0:1275	= 100.7437f 0:1276	= 125.8163f 0:1277	= 100.7437f
+0:1278	= 344.9631f 0:1279	= 691.2000f 0:1280	= 99.7560f
+0:1281	= 23.2136f 0:1282	= 61.8936f 0:1283	= 218.3280f
+0:1284	= 33.5880f 0:1285	= 345.6000f 0:1286	= 218.3280f
+0:1287	= 35.1888f 0:1288	= 21.6000f 0:1289	= 24.0000f
+0:1290	= 75.2112f 0:1291	= 384.1056f 0:1292	= 1.4944p
+0:1293	= 125.8163f 0:1294	= 100.7437f 0:1295	= 125.8163f
+0:1296	= 100.7437f 0:1297	= 125.8163f 0:1298	= 100.7437f
+0:1299	= 344.9631f 0:1300	= 691.2000f 0:1301	= 99.7560f
+0:1302	= 23.2136f 0:1303	= 61.8936f 0:1304	= 218.3280f
+0:1305	= 33.5880f 0:1306	= 345.6000f 0:1307	= 218.3280f
+0:1308	= 35.1888f 0:1309	= 21.6000f 0:1310	= 24.0000f
+0:1311	= 75.2112f 0:1312	= 384.1056f 0:1313	= 1.4944p

```

Opening plot unit= 15
file=gdram0.tr0

** spice file created for circuit gaasdram0 1/10/93 mike morris
***** transient analysis tnom= 25.000 temp= 25.000
*****
vds_avgpwr = -2.4510E+00 from= 0.0000E+00 to= 6.0000E-08
vrefb_avgpwr = -9.1525E-04 from= 0.0000E+00 to= 6.0000E-08
vrefd_avgpwr = 1.3509E-06 from= 0.0000E+00 to= 6.0000E-08
vss_avgpwr = -1.5365E-01 from= 0.0000E+00 to= 6.0000E-08

***** job concluded
** spice file created for circuit gaasdram0 1/10/93 mike morris
***** job statistics summary tnom= 25.000 temp= 25.000
*****
# nodes = 9864 # elements= 4423 # real*8 mem avail/used= 1000000/ 945198
# diodes= 0 # bjts = 0 # jfets = 4324 # mosfets = 0

analysis time # points tot. iter conv.ite
op point 119.45 1 74
transient 41472.89 121 20785 1348 rev= 1086
input+setup 1050.62
pass1 13.91
readin 95.55
errchk 268.71
setup 672.45
output: 0.13
total cpu time 42642.29 seconds
job started at 10:47:32 6-feb93
job ended at 11:24: 7 7-feb93

```

I am done with gdram0.sp
 Sun Feb 7 11:24:09 PST 1993

2. Run #2 LISTING FILE (Abbreviated)

```

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
reading design configuration file: gdram1.cfg
**warning** illegal config file syntax on line=21
of file=gdram1.cfg
=>plotsetup pr12 pscript<=

```

```

***warning** illegal config file syntax on line=21
of file=gdrml.cfg
=>plotsetup pr12 pscript<=
setting user memory from config file to 1000000 words. ( 8000000 bytes)

***** h s p i c e 9007d 10:41:55 6-feb93 sun
** spice file created for circuit gaasdrml.sp 1/10/93 mike morris
***** copyright 1990 meta-software inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
**

** node: 0 = gnd
** node: 1 = vdd
probe q1=v(651) q2=v(816) q0n=v(472) q1n=v(473) q2n=v(467)
+ ao0=v(439) aol=v(600) ao2=v(599)
+ ma2cdo=v(548) ma2cde=v(459) ma2rc6=v(546) ma2rc4=v(545) ma2rc2=v(523)
+ ma2rc0=v(506) ma2rc7=v(461) ma2rc5=v(460) ma2rc3=v(463) ma2rc1=v(464)
+ ma2epu=v(507) ma2epd=v(483) ma2opu=v(462) ma2opd=v(482)
+ ma2ebio=v(455) ma2obio=v(450)
+ malcdo=v(360) malcde=v(312) malrc6=v(359) malrc4=v(358) malrc2=v(347)
+ malrc0=v(337) malrc7=v(314) malrc5=v(313)

.options fast ft=0.95 fs=.95 imin=16.0 imax=16.0 delmax=1.0s rmax=8.0
+ scale=1e-06 brief=0 nopage measout post probe gmindc=1e-11 captab acct

*.options scale=1e-06 probe post gmindc=1e-11 acct captab
.end

**warning** the fast option decreases the cpu time but results may be
less accurate.
***fast option sets default value of the options:
dvdt= 1 rmax= 8.00 fs= 950.00m ft= 950.00m
relvar= 400.00m absvar= 1.00 relmos= 100.00m absmos= 10.00u
**warning** could not find branch element 0:vrvrif
branch - output ignored
** spice file created for circuit gaasdrml.sp 1/10/93 mike morris
Opening plot unit= 15
file=gdrml.tr0

** spice file created for circuit gaasdrml.sp 1/10/93 mike morris
***** transient analysis tnom= 25.000 temp= 25.000
*****
vds_avgpwr = -2.4510E+00 from= 0.0000E+00 to= 6.0000E-08
vrefb_avgpwr = -9.1525E-04 from= 0.0000E+00 to= 6.0000E-08
vrefd_avgpwr = 1.3509E-06 from= 0.0000E+00 to= 6.0000E-08
vss_avgpwr = -1.5365E-01 from= 0.0000E+00 to= 6.0000E-08

```

```

***** job concluded
** spice file created for circuit gaasdram1.sp 1/10/93 mike morris
***** job statistics summary      tnom= 25.000 temp= 25.000
*****
# nodes = 9864 # elements= 4423 # real*8 mem avail/used= 1000000/ 945198
# diodes= 0 # bjts = 0 # jfets = 4324 # mosfets = 0

analysis   time   # points tot. iter conv.iter

op point    119.34     1    74
transient   41435.61   121  20785   1348 rev= 1086
input+setup  1049.63
pass1        13.93
readin       95.62
errchk       267.69
setup         672.39
output        0.11
total cpu time 42603.93 seconds
job started at 10:41:55 6-feb93
job ended at 11:19:20 7-feb93

```

I am done with gdram1.sp
Sun Feb 7 11:19:22 PST 1993

3. Run #3 LISTING FILE (Abbreviated)

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
reading design configuration file: gdram2.cfg
setting user memory from config file to 1000000 words. (8000000 bytes)

```

***** h s p i c e  9007d      13:26:15 7-feb93 sun
** spice file created for circuit gdram2.sp 1/7/93
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
**

** node: 0 = gnd
** node: 1 = vdd
.probe ma1rc3=v(316) ma1rc1=v(317) malepu=v(338) malepd=v(329) malopu=v(315)
+ malopd=v(318) malebio=v(311) malobio=v(306)
+ ph1=v(297) ph1l=v(177) ph2=v(243) ph2ld=v(191)
+ ma0cdo=v(218) ma0cde=v(178) ma0rc6=v(216) ma0rc4=v(215) ma0rc2=v(206)

```

```

+ ma0rc0=v(193) ma0rc7=v(181) ma0rc5=v(180) ma0rc3=v(186) ma0rc1=v(189)
+ ma0epu=v(195) ma0epd=v(192) ma0opu=v(184) ma0opd=v(190)
+ ma0ebio=v(174) ma0obio=v(168)
+ ev=v(183) evu=v(175) od=v(219) odu=v(169)

.options fast ft=.95 fs=.95 imin=16.0 imax=16.0 delmax=1.0s rmax=8.0
+ scale=1e-06 brief=0 nopage measout post probe gmindc=1e-11 captab acct
*.options scale=1e-06 probe post gmindc=1e-11 acct captab
.end
**warning** the fast option decreases the cpu time but results may be
less accurate.
***fast option sets default value of the options:
dvdt= 1 rmax= 8.00 fs= 950.00m ft= 950.00m
relvar= 400.00m absvar= 1.00 relmos= 100.00m absmos= 10.00u
**warning** could not find branch element 0:vrvr
branch - output ignored
** spice file created for circuit gdram2.sp 1/7/93
Opening plot unit= 15
file=gdram2.tr0

** spice file created for circuit gdram2.sp 1/7/93
***** transient analysis tnom= 25.000 temp= 25.000
*****
vds_avgpwr = -2.4510E+00 from= 0.0000E+00 to= 6.0000E-08
vrefb_avgpwr = -9.1525E-04 from= 0.0000E+00 to= 6.0000E-08
vrefd_avgpwr = 1.3509E-06 from= 0.0000E+00 to= 6.0000E-08
vss_avgpwr = -1.5365E-01 from= 0.0000E+00 to= 6.0000E-08

***** job concluded
** spice file created for circuit gdram2.sp 1/7/93
***** job statistics summary tnom= 25.000 temp= 25.000
*****

# nodes = 9864 # elements= 4423 # real*8 mem avail/used= 1000000/ 945318
# diodes= 0 # bjts = 0 # jfets = 4324 # mosfets = 0

analysis time # points tot. iter conv. iter

op point 120.28 1 74
transient 41639.32 241 20785 1348 rev= 1086
input+setup 1052.76
pass1 14.15
readin 95.82
errchk 268.98
setup 673.81
output 0.12
total cpu time 42811.84 seconds
job started at 13:26:15 7-feb93
job ended at 14:35: 2 8-feb93

```

I am done with gdram2.sp
Mon Feb 8 14:35:06 PST 1993

4. Run #4 LISTING FILE (Abbreviated)

Using: /tools3/cad/meta/h9007/sun4.1/hspice
lic: license granted by the license server for hspice
lic: from permit file: /tools3/cad/meta/h9007/permit.hsp
reading install configuration file: /tools3/cad/meta/h9007/meta.cfg
reading design configuration file: gdram3.cfg
setting user memory from config file to 1000000 words. (8000000 bytes)

```
***** h s p i c e  9007d      13:26:27  7-feb93  sun
** spice file created for circuit gdram3.sp 2/7/93
***** copyright 1990 meta-software,inc. *****site:
***** input listing
*****
* hspice.ini
** technology: edgaas
**

** node: 0 = gnd
** node: 1 = vdd
tran 250ps 60ns

.measure tran vds_avgpwr avg p(vds) from 0.0ns to 60ns
.measure tran vrefb_avgpwr avg p(vrefb) from 0.0ns to 60ns
.measure tran vrefd_avgpwr avg p(vrefd) from 0.0ns to 60ns
.measure tran vrvrref_avgpwr avg p(vrvrif) from 0.0ns to 60ns
.measure tran vss_avgpwr avg p(vss) from 0.0ns to 60ns

.probe tran p(vds) p(vss) p(vrefb) p(vrefd) p(vrvrif) power
*
          80 columns->>*
.probe da7=v(182) da6=v(217) da5=v(179) da4=v(214) da3=v(187) da2=v(205)
+ da1=v(188) da0=v(194)
+ do0=v(147) do1=v(139) do2=v(131) do3=v(123)
+ drdy=v(107) mbsy=v(115) refresh=v(1124) irefresh=v(466) mrefresh=v(598)

.options fast ft=0.95 fs=.95 imin=16.0 imax=16.0 delmax=1.0s rmax=8.0
+ scale=1e-06 brief=0 nopage measout post probe gmindc=1e-11 captab acct
.end

**warning** the fast option decreases the cpu time but results may be
less accurate.
```

```

***fast option sets default value of the options:
dvdt= 1      rmax= 8.00    fs= 950.00m   ft= 950.00m
relvar= 400.00m absvar= 1.00 relmos= 100.00m absmos= 10.00u
**warning** could not find branch element 0:vrvr
branch - output ignored
** spice file created for circuit gdram3.sp 2/7/93
Opening plot unit= 15
file=gdram3.tr0

** spice file created for circuit gdram3.sp 2/7/93
***** transient analysis          tnom= 25.000 temp= 25.000
*****
vds_avgpwr = -2.4510E+00 from= 0.0000E+00 to= 6.0000E-08
vrefb_avgpwr = -9.1525E-04 from= 0.0000E+00 to= 6.0000E-08
vrefd_avgpwr = 1.3509E-06 from= 0.0000E+00 to= 6.0000E-08
vss_avgpwr = -1.5365E-01 from= 0.0000E+00 to= 6.0000E-08

***** job concluded
** spice file created for circuit gdram3.sp 2/7/93
***** job statistics summary      tnom= 25.000 temp= 25.000
*****

# nodes = 9864 # elements= 4423 # real*8 mem avail/used= 1000000/ 945278
# diodes= 0 # bjts = 0 # jfets = 4324 # mosfets = 0

analysis   time   # points tot. iter conv.ite
op point   121.01   1   74
transient  41769.61  241  20785  1348 rev= 1086
input+setup 1051.88
pass1       13.80
readin      95.87
errchk      268.04
setup        674.17
output       0.11
total cpu time 42941.87 seconds
job started at 13:26:27 7-feb93
job ended   at 14:37:30 8-feb93

```

I am done with gdram3.sp
Mon Feb 8 14:37:33 PST 1993

U. Original HSPICE GaAs DRAM Source File

```

HSPICE -- gaasdram.sp -- 06 August 1992
* ***** HSPICE VERSION *****
* include Vitesse HGAAs3 models and parameters for hspice.
.pro`ct
.include '/tools3/cad/meta/h9007/lib/vitesse/hgaas3.models'
.lib '/tools3/cad/meta/h9007/lib/vitesse/hgaas3.corners' tt

```

```

.unprotect
*****
* Total pull-down/pull-up ratio is 16 to 1.
*****
* Subcircuit SBFL 2-input NOR
*           INA INB OUTPUT POWER GROUND
.SUBCKT S2NOR 1 2 3 4 5
* D G S B
J0 8 1 5 0 JFET04 L=1.2 W=48.0
J1 8 2 5 0 JFET04 L=1.2 W=48.0
J2 4 8 8 0 JFET16 L=1.2 W=3.0
J3 4 8 3 0 JFET04 L=1.2 W=48.0
J4 3 2 5 0 JFET04 L=1.2 W=48.0
J5 3 1 5 0 JFET04 L=1.2 W=48.0
.ENDS S2NOR
*****
* Subcircuit SBFL 3-input NOR
*           INA INB INC OUTPUT POWER GROUND
.SUBCKT S3NOR 1 2 3 4 5 6
* D G S B
J0 8 1 6 0 JFET04 L=1.2 W=48.0
J1 8 2 6 0 JFET04 L=1.2 W=48.0
J2 8 3 6 0 JFET04 L=1.2 W=48.0
J3 5 8 8 0 JFET16 L=1.2 W=3.0
J4 5 8 4 0 JFET04 L=1.2 W=48.0
J5 4 1 6 0 JFET04 L=1.2 W=48.0
J6 4 2 6 0 JFET04 L=1.2 W=48.0
J7 4 3 6 0 JFET04 L=1.2 W=48.0
.ENDS S3NOR
*****
* Subcircuit SBFL 4-input NOR
*           INA INB INC IND OUTPUT POWER GROUND
.SUBCKT S4NOR 1 2 3 4 5 6 7
* D G S B
J0 8 1 7 0 JFET04 L=1.2 W=48.0
J1 8 2 7 0 JFET04 L=1.2 W=48.0
J2 8 3 7 0 JFET04 L=1.2 W=48.0
J3 8 4 7 0 JFET04 L=1.2 W=48.0
J4 6 8 8 0 JFET16 L=1.2 W=3.0
J5 6 8 5 0 JFET04 L=1.2 W=48.0
J6 5 1 7 0 JFET04 L=1.2 W=48.0
J7 5 2 7 0 JFET04 L=1.2 W=48.0
J8 5 3 7 0 JFET04 L=1.2 W=48.0
J9 5 4 7 0 JFET04 L=1.2 W=48.0
.ENDS S4NOR
*****
* Subcircuit SBFL 3-input OR
*           INA INB INC OUTPUT POWER GROUND
.SUBCKT S3OR 1 2 3 4 5 6
* INA INB INC OUT PWR GND SUBNAME
X0 1 2 3 7 5 6 S3NOR

```

```

X1 7      4 5 6 SINV
.ENDS S3OR
*****
* Subcircuit SBFL 2-input NAND
*           INA INB OUTPUT POWER GROUND
.SUBCKT SS2NAND 1 2 3 4 5
* INA INB OUT PWR GND SUBNAME
X0 1      9 4 5 SINV
X1 2      6 4 5 SINV
X2 9 6    7 4 5 S2NOR
X3 7      3 4 5 SINV
.ENDS SS2NAND
*****
* Subcircuit SBFL 4-input NAND
*           INA INB INC IND OUTPUT POWER GROUND
.SUBCKT SS4NAND 1 2 3 4 5 6 7
* INA INB INC IND OUT PWR GND SUBNAME
X0 1      9 6 7 SINV
X1 2      10 6 7 SINV
X2 3      11 6 7 SINV
X3 4      12 6 7 SINV
X4 9 10 11 12 8 6 7 S4NOR
X5 8      5 6 7 SINV
.ENDS SS4NAND
*****
* Subcircuit SBFL 3-input AND
*           INA INB INC OUTPUT POWER GROUND
.SUBCKT SS3AND 1 2 3 4 5 6
* INA INB INC OUT PWR GND SUBNAME
X0 1      9 5 6 SINV
X1 2      10 5 6 SINV
X2 3      11 5 6 SINV
X3 9 10 11 4 5 6 S3NOR
.ENDS SS3AND
*****
* Subcircuit SBFL 4-input AND
*           INA INB INC IND OUTPUT POWER GROUND
.SUBCKT SS4AND 1 2 3 4 5 6 7
* INA INB INC IND OUT PWR GND SUBNAME
X0 1      9 6 7 SINV
X1 2      10 6 7 SINV
X2 3      11 6 7 SINV
X3 4      12 6 7 SINV
X4 9 10 11 12 5 6 7 S4NOR
.ENDS SS4AND
*****
* Subcircuit SBFL INVERTER
*           INPUT OUTPUT POWER GROUND
.SUBCKT SINV 1 2 3 4
* D G S B
J09 1 4 0 JFET04 L=1.2 W=48.0

```

J1 3 9 9 0 JFET16 L=1.2 W=3.0
J2 3 9 2 0 JFET04 L=1.2 W=48.0
J3 2 1 4 0 JFET04 L=1.2 W=48.0
.ENDS SINV

* Subckt HSPICE SBFL LARGE 2-input NOR - Used in CLOCK
* INPUT OUTPUT POWER GROUND

.SUBCKT CSNOR 1 2 3 4 5
* D G S B

J0 8 1 5 0 JFET04 L=1.2 W=144.0
J1 8 2 5 0 JFET04 L=1.2 W=144.0
J2 4 8 8 0 JFET16 L=1.2 W= 9.0
J3 4 8 3 0 JFET04 L=1.2 W=144.0
J4 3 2 5 0 JFET04 L=1.2 W=144.0
J5 3 1 5 0 JFET04 L=1.2 W=144.0
.ENDS CSNOR

* HSPICE SBFL EXTRA-LARGE DRIVER-INVERTER SUBCIRCUIT - Used in CLOCK
* INPUT OUTPUT POWER GROUND

.SUBCKT SSINV 1 2 3 4
* D G S B

J0 9 1 4 0 JFET04 L=1.2 W=768.0
J1 3 9 9 0 JFET16 L=1.2 W= 48.0
J2 3 9 2 0 JFET04 L=1.2 W=768.0
J3 2 1 4 0 JFET04 L=1.2 W=768.0
.ENDS SSINV

* HSPICE SBFL LARGE DRIVER-INVERTER SUBCIRCUIT - Used in CLOCK
* INPUT OUTPUT POWER GROUND

.SUBCKT CSINV 1 2 3 4
* D G S B

J0 9 1 4 0 JFET04 L=1.2 W=256.0
J1 3 9 9 0 JFET16 L=1.2 W= 16.0
J2 3 9 2 0 JFET04 L=1.2 W=384.0
J3 2 1 4 0 JFET04 L=1.2 W=384.0
.ENDS CSINV

* Subcircuit LVL Level-Shifter to Drive D-mode MESFETs
* USE HSPICE Diode Models for Backconnected MESFETS

* INPUT OUTPUT VDS VSS

.SUBCKT LVL 1 2 3 4

* LVL is logically inverting, hence pre-invert using DINV
* INPUT OUTPUT POWER GROUND SUBNAME

X0 1 25 3 0 DINV

* D G S B

J1 3 25 6 4 JFET04 L=1.2 W=20.0
J2 7 6 7 4 DIO16 L=1.2 W=4.0
J3 7 4 4 4 JFET20 L=3.0 W=3.0
J4 3 9 9 4 JFET16 L=1.2 W=3.0
J5 9 7 0 4 JFET16 L=1.2 W=10.0
J6 3 9 10 4 JFET16 L=1.2 W=20.0

```

J7 11 10 11 4 DIO16 L=1.2 W=20.0
J8 2 11 2 4 DIO16 L=1.2 W=20.0
J9 2 4 4 4 JFET16 L=1.2 W=12.0
J10 12 2 12 4 DIO16 L=1.2 W=10.0
J11 13 12 13 4 DIO16 L=1.2 W=10.0
J12 14 13 14 4 DIO16 L=1.2 W=10.0
J13 4 14 4 4 DIO16 L=1.2 W=10.0
ENDS LVL
*****
* Subcircuit DELAY - generates Clock Pulse Delay
* INPUT OUTPUT POWER GROUND
.SUBCKT DELAY 1 2 3 4
* INA INB OUT POWER GROUND SUBNAME
X0 1 9 3 4 BDINV
X1 9 6 3 4 BDINV
X2 1 6 2 3 4 BS2AND
ENDS DELAY
*****
* Subcircuit CLOCK - two-phase SBFL clock
* INCLK PH1 PH2 PH2D PH1L PH2LD POWER1 POWER2 GROUND
.SUBCKT CLOCK 1 2 3 4 5 6 7 8 9
* INA INB OUT PWR GND SUBNAME
X0 1 2 10 7 9 CSNOR
X1 10 11 7 9 SSINV
X2 11 3 7 9 SSINV
X3 12 3 13 7 9 CSNOR
X4 13 14 7 9 SSINV
X5 14 2 7 9 SSINV
X6 1 12 7 9 CSINV
X7 3 4 7 9 DELAY
X8 2 5 7 8 LVL
X9 4 6 7 8 LVL
ENDS CLOCK
*****
* Subcircuit DCFL INVERTER
* INPUT OUTPUT POWER GROUND
.SUBCKT DINV 1 2 3 4
* D G S B
J0 3 2 2 4 JFET16 L=1.2 W=6.0
J1 2 1 4 4 JFET04 L=1.2 W=96.0
ENDS DINV
*****
* Subcircuit DCFL LARGE INVERTER
* INPUT OUTPUT POWER GROUND
.SUBCKT BDINV 1 2 3 4
* D G S B
j0 3 2 2 4 JFET20 L=3.0 W=40.0
J1 2 1 4 4 JFET04 L=1.2 W=240.0
ENDS BDINV
*****
* Subcircuit SBFL LARGE 2-input NOR

```

```

*          INA INB OUTPUT POWER GROUND
.SUBCKT BS2NOR  1  2  3  4  5
* D G S B
J0 8 1 5 0 JFET04 L=1.2 W=180.0
J1 8 2 5 0 JFET04 L=1.2 W=180.0
J2 4 8 8 0 JFET16 L=1.2 W=10.0
J3 4 8 3 0 JFET04 L=1.2 W=224.0
J4 3 2 5 0 JFET04 L=1.2 W=224.0
J5 3 1 5 0 JFET04 L=1.2 W=224.0
.ENDS  BS2NOR
***** ****
* Subcircuit SBFL LARGE 2- input AND
*          INA INB OUTPUT POWER GROUND
.SUBCKT BS2AND  1  2  3  4  5
* INA INB OUT PWR GND SUBNAME
X0 1      9  4  5  BDINV
X1 2      6  4  5  BDINV
X2 9      6  3  4  5  BS2NOR
.ENDS  BS2AND
***** ****
*Subcircuit DCFL 2-INPUT NON-DeMORGAN NAND
*          INA INB OUTPUT POWER GROUND
.SUBCKT D2NAND  1  2  3  4  5
* D G S B
J0 4 3 3 5 JFET16 L=1.2 W=6.0
J1 3 1 6 5 JFET04 L=1.2 W=192.0
J2 6 2 5 5 JFET04 L=1.2 W=192.0
.ENDS  D2NAND
***** ****
*Subcircuit DCFL 2-INPUT NON-DeMORGAN AND
*          INA INB OUTPUT POWER GROUND
.SUBCKT D2AND   1  2  3  4  5
* INA INB OUT PWR GND SUBNAME
X0 1      2  6  4  5  D2NAND
X1 6      3  4  5  DINV
.ENDS  D2AND
***** ****
*Subcircuit DCFL 2-INPUT NOR
*          INA INB OUTPUT POWER GROUND
.SUBCKT D2NOR   1  2  3  4  5
* D G S B
J0 4 3 3 5 JFET16 L=1.2 W=6.0
J1 3 1 5 5 JFET04 L=1.2 W=96.0
J2 3 2 5 5 JFET04 L=1.2 W=96.0
.ENDS  D2NOR
***** ****
*Subcircuit DCFL 2-INPUT DeMORGAN AND
*          INA INB OUTPUT POWER GROUND
.SUBCKT DD2AND  1  2  3  4  5
* INA INB OUT PWR GND SUBNAME
X0 1      10 4  5  DINV

```

```

X1 2      11  4   5 DINV
X2 10    11  3 4 5 D2NOR
.ENDS DD2AND
*****
*Subcircuit DCFL 2-INPUT DeMORGAN NAND
*           INA INB OUTPUT POWER GROUND
.SUBCKT DD2NAND 1  2   3   4   5
*  INA INB OUT PWR GND SUBNAME
X0 1      10  4   5 DINV
X1 2      11  4   5 DINV
X2 10    11  12  4   5 D2NOR
X3 12    3   4   5 DINV
.ENDS DD2NAND
*****
* Subcircuit DCFL 2-INPUT DeMORGAN OR
*           INA INB OUTPUT POWER GROUND
.SUBCKT DD2OR  1  2   3   4   5
*  INA INB OUT PWR GND SUBNAME
X0 1      2   6   4   5 D2NOR
X1 6      3   4   5 DINV
.ENDS DD2OR
*****
* Subcircuit DCFL 3-INPUT DeMORGAN OR
*           INA INB INC OUTPUT POWER GROUND
.SUBCKT DD3OR  1  2   3   4   5   6
*  INA INB INC OUT PWR GND SUBNAME
X0 1      2   3   7   5   6 D3NOR
X1 7      4   5   6 DINV
.ENDS DD3OR
*****
* Subcircuit DCFL 4-INPUT DeMORGAN OR
*           INA INB INC IND OUTPUT POWER GROUND
.SUBCKT DD4OR  1  2   3   4   5   6   7
*  INA INB INC IND OUT PWR GND SUBNAME
X0 1      2   3   4   8   6   7 D4NOR
X1 8      5   6   7 DINV
.ENDS DD4OR
*****
* Subcircuit DCFL 3-INPUT NOR
*           INA INB INC OUTPUT POWER GROUND
.SUBCKT D3NOR  1  2   3   4   5   6
*  D G S B
J0 5 4 4 6 JFET16 L=1.2 W=6.0
J1 4 1 6 6 JFET04 L=1.2 W=96.0
J2 4 2 6 6 JFET04 L=1.2 W=96.0
J3 4 3 6 6 JFET04 L=1.2 W=96.0
.ENDS D3NOR
*****
*Subcircuit DCFL 3-INPUT DeMORGAN AND
*           INA INB INC OUTPUT POWER GROUND
.SUBCKT DD3AND 1  2   3   4   5   6

```

* INA INB INC OUT PWR GND SUBNAME

X0 1 10 5 6 DINV
X1 2 11 5 6 DINV
X2 3 12 5 6 DINV
X3 10 11 12 4 5 6 D3NOR
.ENDS DD3AND

*Subcircuit DCFL 3-INPUT DeMORGAN NAND

* INA INB INC OUTPUT POWER GROUND
.SUBCKT DD3NAND 1 2 3 4 5 6

* INA INB INC OUT PWR GND SUBNAME
X0 1 10 5 6 DINV
X1 2 11 5 6 DINV
X2 3 12 5 6 DINV
X3 10 11 12 13 5 6 D3NOR
X4 13 4 5 6 DINV
.ENDS DD3NAND

*Subcircuit DCFL 4-INPUT NOR

* INA INB INC IND OUTPUT POWER GROUND
.SUBCKT D4NOR 1 2 3 4 5 6 7

* D G S B
J0 6 5 5 7 JFET16 L=1.2 W=6.0
J1 5 1 7 7 JFET04 L=1.2 W=96.0
J2 5 2 7 7 JFET04 L=1.2 W=96.0
J3 5 3 7 7 JFET04 L=1.2 W=96.0
J4 5 4 7 7 JFET04 L=1.2 W=96.0
.ENDS D4NOR

*Subcircuit DCFL 4-INPUT DeMORGAN NAND

* INA INB INC IND OUTPUT POWER GROUND
.SUBCKT DD4NAND 1 2 3 4 5 6 7

* INA INB INC IND OUT PWR GND SUBNAME
X0 1 10 6 7 DINV
X1 2 11 6 7 DINV
X2 3 12 6 7 DINV
X3 4 13 6 7 DINV
X4 10 11 12 13 14 6 7 D4NOR
X5 14 5 6 7 DINV
.ENDS DD4NAND

*Subcircuit DCFL 4-INPUT DeMORGAN AND

* INA INB INC IND OUTPUT POWER GROUND
.SUBCKT DD4AND 1 2 3 4 5 6 7

* INA INB INC IND OUT PWR GND SUBNAME
X0 1 10 6 7 DINV
X1 2 11 6 7 DINV
X2 3 12 6 7 DINV
X3 4 13 6 7 DINV
X4 10 11 12 13 5 6 7 D4NOR
.ENDS DD4AND

```
*****
* Subcircuit DCFL D-LATCH Using Generic Gates
*           D CLK Q /Q POWER GROUND
.SUBCKT DLATCH 1 2 3 4 5 6
*  INA INB OUTPUT POWER GROUND SUBNAME
X0 1 2 8 5 6 D2NAND
X1 1 7 5 6 DINV
X2 2 7 9 5 6 D2NAND
X3 8 4 3 5 6 D2NAND
X4 9 3 4 5 6 D2NAND
.ENDS DLATCH
*****
* Subcircuit SBFL/DCFL SD-LATCH Using Generic Gates First Stage
*           D CLK Q /Q POWER GROUND
.SUBCKT SDLATCH 1 2 3 4 5 6
*  INA INB OUTPUT POWER GROUND SUBNAME
X0 1 2 8 5 6 D2NAND
X1 1 7 5 6 DINV
X2 2 7 9 5 6 D2NAND
X3 8 4 3 5 6 SS2NAND
X4 9 3 4 5 6 SS2NAND
.ENDS SDLATCH
*****
* Subcircuit SBFL DFF D Flip-Flop
***           D CLK Q /Q POWER GROUND
.SUBCKT DFF 1 2 3 4 5 6
*  INA INB D CLK Q /Q OUT POWER GROUND SUBNAME
X0 1 9 7 8 5 6 DLATCH
X1 2 9 5 6 DINV
X2 9 10 5 6 DINV
X3 7 10 3 4 5 6 DLATCH
.ENDS DFF
*****
* Subcircuit DCFL CPDFF Clear D Flip Flop
* Wakerly pg 363 - 31July 1992
***           D CLK CLR Q /Q POWER GROUND
.SUBCKT CPDFF 1 2 3 4 5 6 7
*  INA INB INC OUT PWR GND SUBNAME
X0 12 10 9 6 7 DD2NAND
X1 9 3 2 10 6 7 DD3NAND
X2 10 2 12 11 6 7 DD3NAND
X3 11 3 1 12 6 7 DD3NAND
X4 10 5 4 6 7 DD2NAND
X5 4 3 11 5 6 7 DD3NAND
.ENDS CPDFF
*****
* Subcircuit DCFL (with SBFL Outputs) D Flip-Flop
***           D CLK Q /Q POWER GROUND
.SUBCKT SDFF 1 2 3 4 5 6
*  INA INB D CLK Q /Q OUT POWER GROUND SUBNAME
X0 1 9 7 8 5 6 DLATCH
```

X1	2		9	5	6	DINV
X2	9		10	5	6	DINV
X3		7 10 3 4		5	6	SDLATCH
ENDS		SDF				

* Subcircuit SBFL/DCFL (Combination) 3-to-8 Non-Latched Decoder

****	A0	A1	A2	W	R	RE	O0	O1	O2	O3	O4	O5	O6	O7	ENBL	PWR	GRND	
.SUBCKT	DECODER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

*** INA INB INC IND OUTPUT POWER GROUND SUBNAME

X0	1		20	16	17	DINV										
X1	2		18	16	17	DINV										
X2	3		19	16	17	DINV										
X3	4	5	6	15	16	17	S3OR									
X4	20	18	19	15	7	16	17	SS4AND								
X5	1	18	19	15	8	16	17	SS4AND								
X6	20	2	19	15	9	16	17	SS4AND								
X7	1	2	19	15	10	16	17	SS4AND								
X8	20	18	3	15	11	16	17	SS4AND								
X9	1	18	3	15	12	16	17	SS4AND								
X10	20	2	3	15	13	16	17	SS4AND								
X11	1	2	3	15	14	16	17	SS4AND								
ENDS		DECODER														

* Subcircuit DCFL 3-bit COUNTER using clear D FFs (CPDFF)

***	ENBLE	CLK	Q0	Q1	Q2	/Q0	/Q1	/Q2	POWER	GROUND
-----	-------	-----	----	----	----	-----	-----	-----	-------	--------

.SUBCKT	COUNTER	1	2	3	4	5	6	7	8	9	10
---------	---------	---	---	---	---	---	---	---	---	---	----

*** INA INB INC IND D CLK CLR Q /Q OUT POWER GROUND SUBNAME

X0	1			11	9	10	DINV	
X1	3	11		12	9	10	DD2AND	
X2	1	6		13	9	10	DD2AND	
X3	12	13		20	9	10	DD2OR	
X4	4	11		14	9	10	DD2AND	
X5	4	6		15	9	10	DD2AND	
X6	3	7	1	16	9	10	DD3AND	
X7	14	15	16	21	9	10	DD3OR	
X8	5	7		17	9	10	DD2AND	
X9	5	6		18	9	10	DD2AND	
X10	1	3	4	8	19	9	10	DD4AND
X11	11	5		23	9	10	DD2AND	
X12	17	18	19	23	22	9	10	DD4OR

*** INA INB INC IND D CLK CLR Q /Q OUT POWER GROUND SUBNAME

X13		20	2	1	3	6		9	10	CPDFF
X14		21	2	1	4	7		9	10	CPDFF
X15		22	2	1	5	8		9	10	CPDFF

ENDS COUNTER

* Subcircuit DCFL/SBFL Combination REFRESH Circuit

*	REF	PH1	A0	A1	A2	A00	A01	A02	MREF	PWR	GND
---	-----	-----	----	----	----	-----	-----	-----	------	-----	-----

.SUBCKT	DREFRESH	1	2	3	4	5	6	7	8	9	10	11
---------	----------	---	---	---	---	---	---	---	---	---	----	----

*** INA INB INC IND D CLK Q /Q OUT POWER GROUND SUBNAME

X0	15	28	29	30		31	10		11	SS4NAND
----	----	----	----	----	--	----	----	--	----	---------

X1	31	2	9	33	10	11	SDFF				
*** ENBLE	CLK	Q0	Q1	Q2 /Q0 /Q1 /Q2	POWER	GROUND					
X2	31	2	25	26	27	28	29	30	10	11	COUNTER
X3	3								12	10	DINV
X4	4								13	10	DINV
X5	5								14	10	DINV
X6	1								15	10	DINV
X7	3	33							16	10	DD2AND
X8	3	25							17	10	DD2AND
X9	12	25	9						18	10	DD3AND
X10	4	33							19	10	DD2AND
X11	4	26							20	10	DD2AND
X12	13	26	9						21	10	DD3AND
X13	5	33							22	10	DD2AND
X14	5	27							23	10	DD2AND
X15	14	27	9						24	10	DD3AND
X16	16	17	18						6	10	DD3OR
X17	19	20	21						7	10	DD3OR
X18	22	23	24						8	10	DD3OR

* Following are initial conditions via HSPICE (Simulation only)

.IC v(25)=0.0 v(26)=0.0 v(27)=0.0 v(31)=0.0 v(9)=0.0

+ v(28)=0.63 v(29)=0.63 v(30)=0.63 v(33)=0.63

ENDS DREFRESH

* Subcircuit SBFL/DCFL Decoder/Driver "DECODDRVER"

** 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

** PH2D A00 A01 A02 MREF MR MW DA0 DA1 DA2 DA3 DA4 DA5 DA6 DA7 EVU
17 18 19 20 21 22

**ODU EV OD PWR1 PWR2 GND

.SUBCKT DECODDRVER 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22

***A0 A1 A2 W R RE O0 O1 O2 O3 O4 O5 O6 O7 ENBL PWR GND SUBNAME

X0 2 3 4 7 6 5 30 31 32 33 34 35 36 37 50 20 22 DECODER

*** INA INB INC IND D CLK Q /Q OUT ENBL PWR GND BULK SUBNAME

X1	2		48	20	22	DINV	
X2	2	1	50	17	20	22	SS3AND
X3	48	1	50	16	20	22	SS3AND
X4	30	1		40	20	22	DD2AND
X5	31	1		41	20	22	DD2AND
X6	32	1		42	20	22	DD2AND
X7	33	1		43	20	22	DD2AND
X8	34	1		44	20	22	DD2AND
X9	35	1		45	20	22	DD2AND
X10	36	1		46	20	22	DD2AND
X11	37	1		47	20	22	DD2AND
X12	40			8	20	21	LVL
X13	41			9	20	21	LVL
X14	42			10	20	21	LVL
X15	43			11	20	21	LVL
X16	44			12	20	21	LVL
X17	45			13	20	21	LVL
X18	46			14	20	21	LVL

X19	47		15	20	21	LVL
X20	16		18	20	21	LVL
X21	17		19	20	21	LVL

.ENDS DECODDRVER

* Subcircuit OUTPUT

* ODDBIO EVENBIO EDUMMY ODUMMY MR Q /Q PWR GND

.SUBCKT OUTPUT 1 2 3 4 5 6 7 8 9

* INA INB INC IND OUT POWER GROUND SUBNAME

X0	1		12	8	9	DINV		
X1	2		13	8	9	DINV		
X2	3		14	8	9	DINV		
X3	4		15	8	9	DINV		
X4	1	4	13	14	17	8	9	DD4AND
X5	12	15	2	3	30	8	9	DD4AND
X6	1	15	2	3	31	8	9	DD4AND
X7	1	4	2	14	20	8	9	DD4AND
X8	17	30	31	20	21	8	9	DD4OR
X9	3	4			22	8	9	DD2OR
X10	5	22			16	8	9	DD2AND
				D CLK Q /Q	POWER	GROUND	SUBNAME	
X11	21	16	6	7		8	9	DLATCH

.ENDS OUTPUT

* Subcircuit WLOGIC - Write Logic

* EPU=Even Pull UP -- Bring in A0 for Even/Odd & Writing

* DATA DAS A0 MW CLK EPU EPD OPU OPD POWER GND VSS

.SUBCKT WLOGIC 1 2 3 4 5 6 7 8 9 10 11 12

* D CLK Q /Q POWER GROUND SUBNAME

X0	1	2	14	15	10	11	DLATCH
----	---	---	----	----	----	----	--------

* INA INB INC IND OUT POWER GROUND SUBNAME

X1	3		13	10	11	DINV		
X2	13	14	4	5	16	10	11	DD4AND
X3	13	15	4	5	7	10	11	DD4AND
X4	4	3	14	5	17	10	11	DD4AND
X5	3	15	4	5	9	10	11	DD4AND
				IN	OUT	VDS	VSS	SUBNAME
X6	16				6	10	12	LVL
X7	17				8	10	12	LVL

.ENDS WLOGIC

* Subcircuit RAM Cell -- One Bit Position by Eight Addresses

* PH1L PH1 PH2LD OxPU OxPD ExPU ExPD EDC ODC DA0 DA1 DA2 DA3 DA4 DA5 DA6 *DA7

EBIO OBIO RCx0 RCx1 RCx2 RCx3 RCx4 RCx5 RCx6 RCx7 RCEx RCOx Pwr Gnd *Vrefb Vrefd

.SUBCKT RAM 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

+ 20 21 22 23 24 25 26 27 28 29 30 31 32 33

* D G S B

J0 30 3 18 31 JFET16 L=1.2 W=9.0

J1 30 3 19 31 JFET16 L=1.2 W=9.0

J2 18 10 20 31 JFET16 L=1.2 W=8.0

J3 18 9 29 31 JFET16 L=1.2 W=8.0
 J4 18 19 31 31 JFET04 L=1.2 W=210.0
 J5 19 18 31 31 JFET04 L=1.2 W=210.0
 J6 19 8 28 31 JFET16 L=1.2 W=8.0
 J7 19 11 21 31 JFET16 L=1.2 W=8.0
 J8 33 1 28 31 JFET16 L=1.2 W=3.0
 J10 30 6 18 31 JFET16 L=1.2 W=185.0
 J11 30 4 19 31 JFET16 L=1.2 W=185.0
 J12 18 7 31 31 JFET04 L=1.2 W=6.0
 J13 19 5 31 31 JFET04 L=1.2 W=6.0
 J14 19 1 18 31 JFET16 L=1.2 W=20.0
 J15 18 12 22 31 JFET16 L=1.2 W=8.0
 J16 18 14 24 31 JFET16 L=1.2 W=8.0
 J17 18 16 26 31 JFET16 L=1.2 W=8.0
 J18 19 13 23 31 JFET16 L=1.2 W=8.0
 J19 19 15 25 31 JFET16 L=1.2 W=8.0
 J20 19 17 27 31 JFET16 L=1.2 W=8.0
 J21 33 1 29 31 JFET16 L=1.2 W=3.0
 J23 32 1 19 31 JFET16 L=1.2 W=6.0
 J25 32 1 18 31 JFET16 L=1.2 W=6.0
 C0 20 31 620FF
 C1 21 31 620FF
 C2 29 31 70FF
 C3 28 31 70FF
 C4 22 31 620FF
 C5 23 31 620FF
 C6 24 31 620FF
 C7 25 31 620FF
 C8 26 31 620FF
 C9 27 31 620FF
 .ENDS RAM

 * Subcircuit WRITEP - Operation Priority Circuit
 *The Call 14 60 61 17 18 1 0 WRITEP
 ***** MREF W R MW MR POWER GROUND

.SUBCKT WRITEP 1 2 3 4 5 6 7
 INA INB INC OUT PWR GND SUBNAME
 X0 1 8 6 7 DINV
 X1 2 9 6 7 DINV
 X2 2 8 4 6 7 DD2AND
 X3 3 9 8 5 6 7 DD3AND

.ENDS WRITEP

 * POWER SUPPLIES

VDS 1 0 DC 2.0V
 VREFB 777 0 DC 0.7V
 VREFD 888 0 DC 0.26V
 VSS 999 0 DC -2.5V

* SIGNAL INPUTS

VCLOCKIN 8 0 PULSE(0.63 0.06 OPS 100PS 100PS 2100PS 4200PS)

*The next 3 lines will count 000 -> 111 with XXX PS up/down times

* Count through all eight addresses for testing purposes

*VA0 2 0 PULSE(0.06 0.63 4200PS 100PS 100PS 4000PS 8400PS)

*VA1 3 0 PULSE(0.06 0.63 8400PS 100PS 100PS 8200PS 16800PS)

*VA2 4 0 PULSE(0.06 0.63 16800PS 100PS 100PS 16600PS 33600PS)

*VA0 2 0 PULSE(0.06 0.63 4.5NS 100PS 100PS 4.3NS 9.0NS)

*VA1 3 0 PULSE(0.06 0.63 9.0NS 100PS 100PS 8.8NS 18.0NS)

*VA2 4 0 PULSE(0.06 0.63 18.0NS 100PS 100PS 17.8NS 36.0NS)

* Address Inputs - Following three lines are steady state DC voltages for testing purposes

VA0 2 0 DC 0.063V

VA1 3 0 DC 0.63V

VA2 4 0 DC 0.63V

* Data Inputs - Following eight lines are steady state DC voltages for testing purposes

VD0 100 0 DC 0.63V

VD1 101 0 DC 0.06V

VD2 102 0 DC 0.63V

VD3 103 0 DC 0.63V

VD4 104 0 DC 0.06V

VD5 105 0 DC 0.06V

VD6 106 0 DC 0.63V

VD7 107 0 DC 0.06V

* Data Strobe - Following line is steady state DC voltage for testing purposes

VDAS 108 0 DC 0.63V

* Write Signal -

VW 60 0 PULSE(0.06 0.63 3NS 100PS 100PS 5000PS 1000MS)

* Read Signals -

*VR 61 0 PULSE(0.06 0.63 OPS 100PS 100PS 8000PS 1000NS)

VR 61 0 0.06V

* Refresh Signals -

*VREF 70 0 0.06V

VREF 70 0 PULSE(0.06 0.63 8000PS 100PS 100PS 4200PS 1000MS)

** Main Circuit **

* Commence Subcircuit Calls

* INCLK PH1 PH2 PH2D PH1L PH2LD POWER1 POWER2 GROUND SUBNAME

X0 8 9 10 89 88 189 1 999 0 CLOCK

* REF PH1 A0 A1 A2 A00 A01 A02 MREF POWER GROUND SUBNAME

X1 70 9 2 3 4 11 12 13 14 1 0 DREFRESH

* MREF W R MW MR POWER GROUND SUBNAME

X2 14 60 61 17 18 1 0 WRITEP

* PH2D A00 A01 A02 MREF MR MW DA0 DA1 DA2 DA3 DA4 DA5 DA6 DA7 EVU

X3 10 11 12 13 14 18 17 20 21 22 23 24 25 26 27 30

** ODU EV OD PWR1 PWR2 GND SUBNAME

```

+ 31 40 41 1 999 0 DECODDRVER
*****
* This circuitry generates the output control signal Data Ready(DRDY) PIN 34
* INA INB OUT PWR GND SUBNAME
X4 30 31 32 1 0 DD2OR
X5 32 18 33 1 0 DD2AND
X6 33 34 1 0 DINV
*****
* This circuitry generates the output control signal Memory Busy (MBSY)PIN 35
* INA INB INC OUT PWR GND SUBNAME
X7 14 17 18 35 1 0 DD3OR
*****
* Commence Subcircuit Calls to RAM, each with its associated OUTPUT & WLOGIC
*****
* SUBCKT RAM -- Call for Data Bit Position ZERO
* PH1L PH1 PH2LD OxPU OxPD ExPU ExPD EDC ODC DA0 DA1 DA2 DA3 DA4 DA5
X8 88 9 189 84 85 82 83 40 41 20 21 22 23 24 25
* DA6 DA7 EBIO OBIO RCx0 RCx1 RCx2 RCx3 RCx4 RCx5 RCx6 RCx7 RCEx RCOx
+ 26 27 98 99 50 51 54 55 56 57 58 59 53 52
* PWR GND VREFB VREFD SUBNAME
+ 1 0 777 888 RAM
* ODDBIO EVENBIO EDUMMY ODUMMY MR Q /Q PWR GND SUBNAME
X9 99 98 30 31 18 300 310 1 0 OUTPUT
* DATA DAS A0 MW PH2 EPU EPD OPU OPD POWER GND VSS SUBNAME
X10 100 108 2 17 10 82 83 84 85 1 0 999 WLOGIC
*****
*****+
* SUBCKT RAM -- Call for Data Bit Position ONE
* PH1L PH1 PH2LD OxPU OxPD ExPU ExPD EDC ODC DA0 DA1 DA2 DA3 DA4 DA5
X20 88 9 189 184 185 182 183 40 41 20 21 22 23 24 25
* DA6 DA7 EBIO OBIO RCx0 RCx1 RCx2 RCx3 RCx4 RCx5 RCx6 RCx7 RCEx RCOx
+ 26 27 198 199 150 151 154 155 156 157 158 159 153 152
* PWR GND VREFB VREFD SUBNAME
+ 1 0 777 888 RAM
* ODDBIO EVENBIO EDUMMY ODUMMY MR Q /Q PWR GND SUBNAME
X21 199 198 30 31 18 301 311 1 0 OUTPUT
* DATA DAS A0 MW PH2 EPU EPD OPU OPD POWER GND VSS SUBNAME
X22 101 108 2 17 10 182 183 184 185 1 0 999 WLOGIC
*****
*****+
* SUBCKT RAM -- Call for Data Bit Position TWO
* PH1L PH1 PH2LD OxPU OxPD ExPU ExPD EDC ODC DA0 DA1 DA2 DA3 DA4 DA5
X23 88 9 189 284 285 282 283 40 41 20 21 22 23 24 25
* DA6 DA7 EBIO OBIO RCx0 RCx1 RCx2 RCx3 RCx4 RCx5 RCx6 RCx7 RCEx RCOx
+ 26 27 298 299 250 251 254 255 256 257 258 259 253 252
* PWR GND VREFB VREFD SUBNAME
+ 1 0 777 888 RAM
* ODDBIO EVENBIO EDUMMY ODUMMY MR Q /Q PWR GND SUBNAME
X24 299 298 30 31 18 302 312 1 0 OUTPUT
* DATA DAS A0 MW PH2 EPU EPD OPU OPD POWER GND VSS SUBNAME
X25 102 108 2 17 10 282 283 284 285 1 0 999 WLOGIC

```

```

*****
***** * SUBCKT RAM -- Call for Data Bit Position THREE
***** * PH1L PH1 PH2LD OxPU OxPD ExPU ExPD EDC ODC DA0 DA1 DA2 DA3 DA4 DA5
X26 88 9 189 384 385 382 383 40 41 20 21 22 23 24 25
* DA6 DA7 EBIO OBIO RCx0 RCx1 RCx2 RCx3 RCx4 RCx5 RCx6 RCx7 RCEx RCOx
+ 26 27 398 399 350 351 354 355 356 357 358 359 353 352
* PWR GND VREFB VREFD SUBNAME
+ 1 0 777 888 RAM
* ODDBIO EVENBIO EDUMMY ODUMMY MR Q /Q PWR GND SUBNAME
X27 399 398 30 31 18 303 313 1 0 OUTPUT
* DATA DAS A0 MW PH2 EPU EPD OPU OPD POWER GND VSS SUBNAME
X28 103 108 2 17 10 382 383 384 385 1 0 999 WLOGIC
*****
***** * SUBCKT RAM -- Call for Data Bit Position FOUR
***** * PH1L PH1 PH2LD OxPU OxPD ExPU ExPD EDC ODC DA0 DA1 DA2 DA3 DA4 DA5
X29 88 9 189 484 485 482 483 40 41 20 21 22 23 24 25
* DA6 DA7 EBIO OBIO RCx0 RCx1 RCx2 RCx3 RCx4 RCx5 RCx6 RCx7 RCEx RCOx
+ 26 27 498 499 450 451 454 455 456 457 458 459 453 452
* PWR GND VREFB VREFD SUBNAME
+ 1 0 777 888 RAM
* ODDBIO EVENBIO EDUMMY ODUMMY MR Q /Q PWR GND SUBNAME
X30 499 498 30 31 18 304 314 1 0 OUTPUT
* DATA DAS A0 MW PH2 EPU EPD OPU OPD POWER GND VSS SUBNAME
X31 104 108 2 17 1C 482 483 484 485 1 0 999 WLOGIC
*****
***** * SUBCKT RAM -- Call for Data Bit Position FIVE
***** * PH1L PH1 PH2LD OxPU OxPD ExPU ExPD EDC ODC DA0 DA1 DA2 DA3 DA4 DA5
X32 88 9 189 584 585 582 583 40 41 20 21 22 23 24 25
* DA6 DA7 EBIO OBIO RCx0 RCx1 RCx2 RCx3 RCx4 RCx5 RCx6 RCx7 RCEx RCOx
+ 26 27 598 599 550 551 554 555 556 557 558 559 553 552
* PWR GND VREFB VREFD SUBNAME
+ 1 0 777 888 RAM
* ODDBIO EVENBIO EDUMMY ODUMMY MR Q /Q PWR GND SUBNAME
X33 599 598 30 31 18 305 315 1 0 OUTPUT
* DATA DAS A0 MW PH2 EPU EPD OPU OPD POWER GND VSS SUBNAME
X34 105 108 2 17 10 582 583 584 585 1 0 999 WLOGIC
*****
***** * SUBCKT RAM -- Call for Data Bit Position SIX
***** * PH1L PH1 PH2LD OxPU OxPD ExPU ExPD EDC ODC DA0 DA1 DA2 DA3 DA4 DA5
X35 88 9 189 684 685 682 683 40 41 20 21 22 23 24 25
* DA6 DA7 EBIO OBIO RCx0 RCx1 RCx2 RCx3 RCx4 RCx5 RCx6 RCx7 RCEx RCOx
+ 26 27 698 699 650 651 654 655 656 657 658 659 653 652
* PWR GND VREFB VREFD SUBNAME
+ 1 0 777 888 RAM
* ODDBIO EVENBIO EDUMMY ODUMMY MR Q /Q PWR GND SUBNAME
X36 699 698 30 31 18 306 316 1 0 OUTPUT
* DATA DAS A0 MW PH2 EPU EPD OPU OPD POWER GND VSS SUBNAME

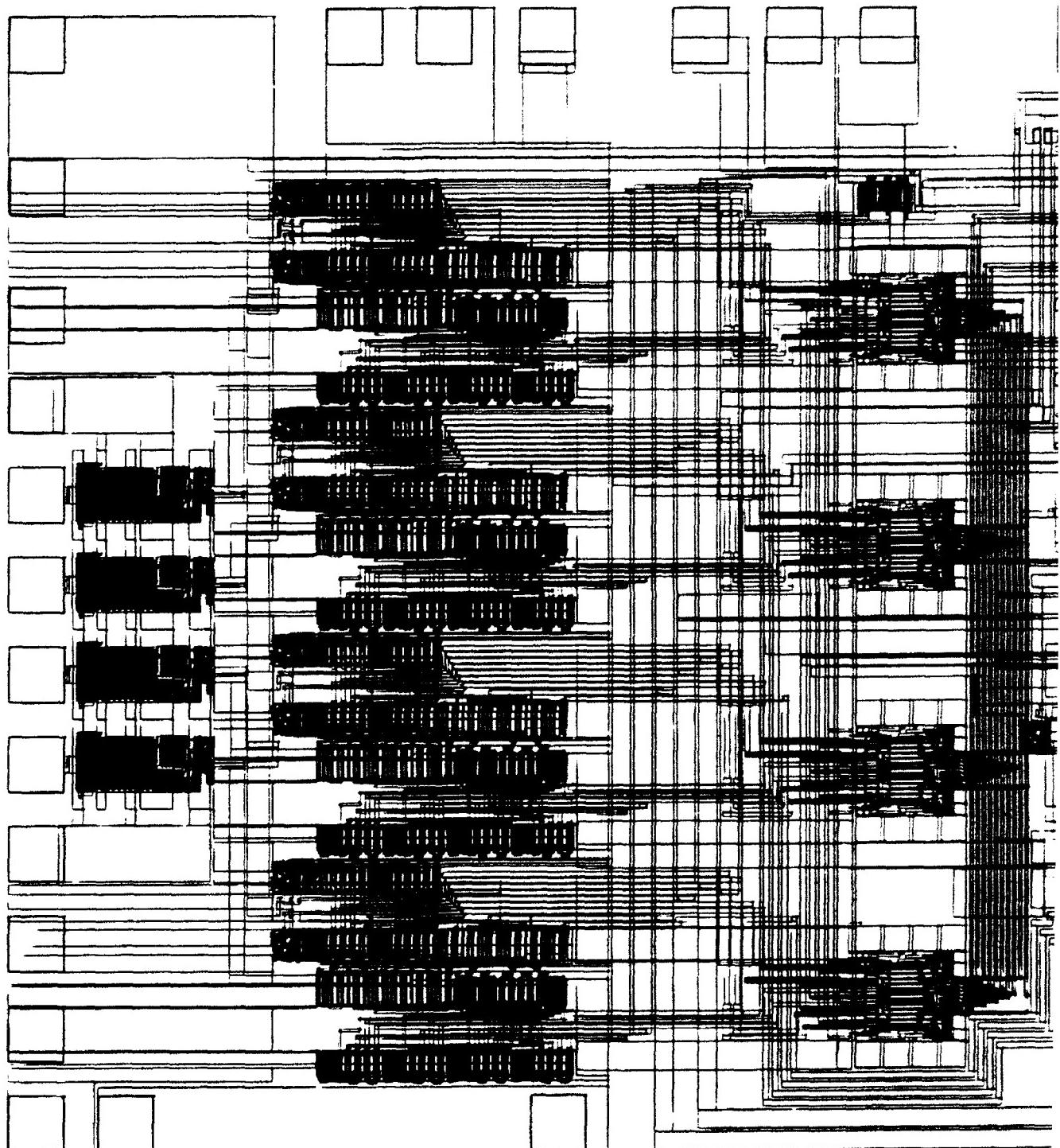
```

X37 106 108 2 17 10 682 683 684 685 1 0 999 WLOGIC

* SUBCKT RAM -- Call for Data Bit Position SEVEN
* PH1L PH1 PH2LD OxPU OxPD ExPU ExPD EDC ODC DA0 DA1 DA2 DA3 DA4 DA5
X38 88 9 189 784 785 782 783 40 41 20 21 22 23 24 25
* DA6 DA7 EBIO OBIO RCx0 RCx1 RCx2 RCx3 RCx4 RCx5 RCx6 RCx7 RCEx RCOx
+ 26 27 798 799 750 751 754 755 756 757 758 759 753 752
* PWR GND VREFB VREFD SUBNAME
+ 1 0 777 888 RAM
* ODDBIO EVENBIO EDUMMY ODUMMY MR Q /Q PWR GND SUBNAME
X39 799 798 30 31 18 307 317 1 0 OUTPUT
* DATA DAS A0 MW PH2 EPU EPD OPU OPD POWER GND VSS SUBNAME
X40 107 108 2 17 10 782 783 784 785 1 0 999 WLOGIC

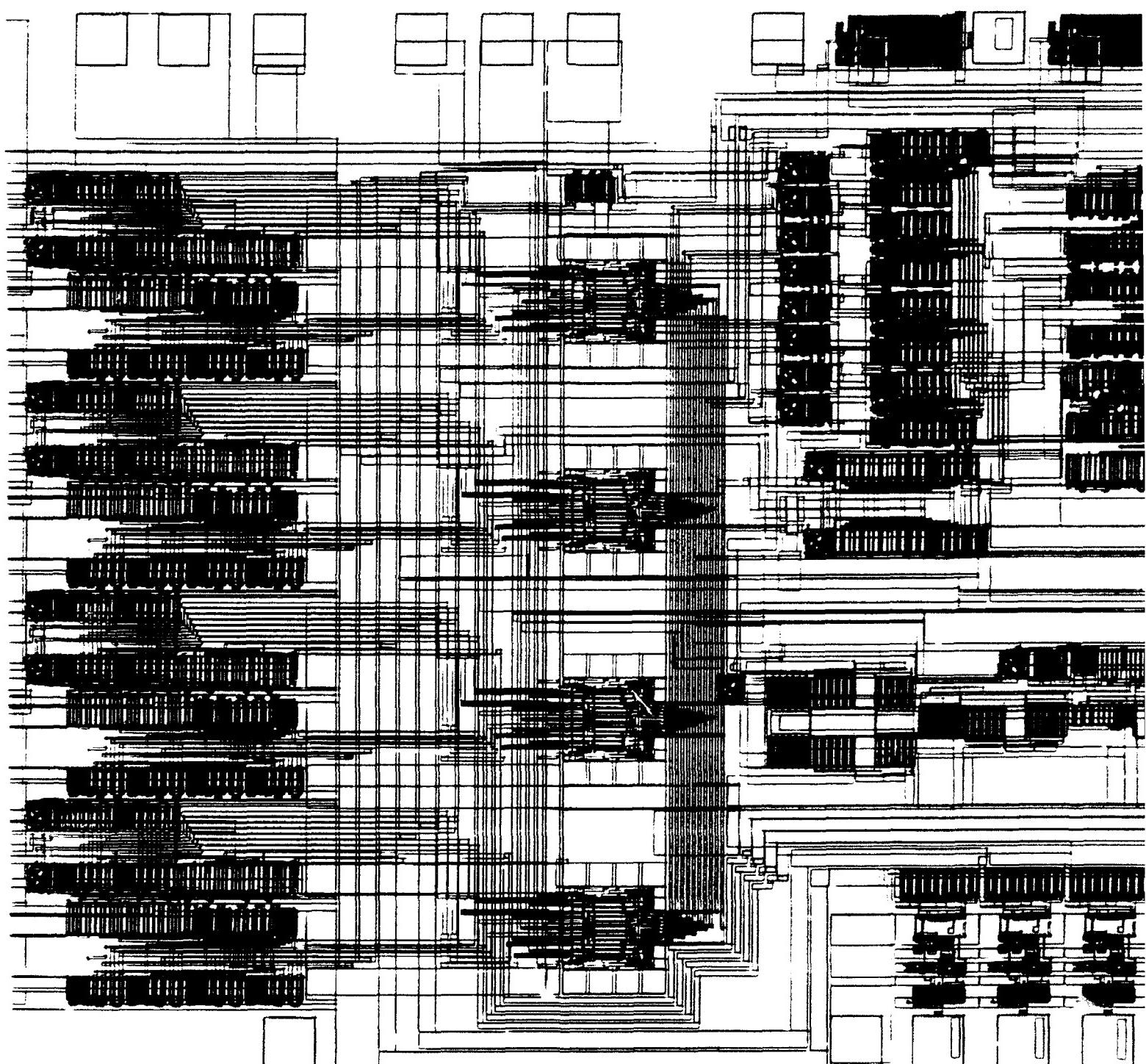
* Following Lines are operating directions for HSPICE
.TRAN 250PS 40.0ns
.options scale=1E-06 post acct captab
.END

APPENDIX B - LAYOUT PLOT OF GaAs DRAM

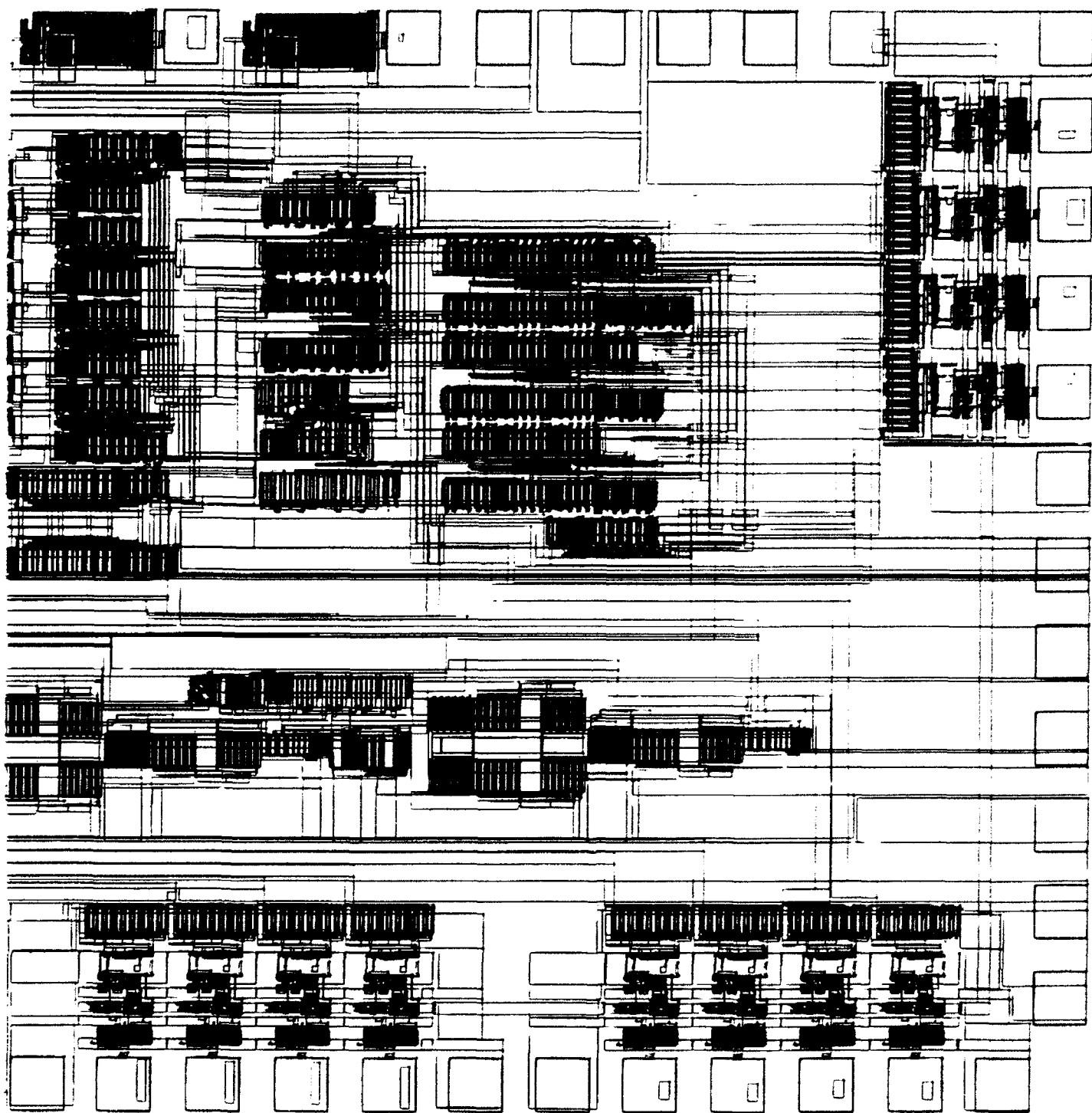


APPENDIX B - LAYOUT PLOT OF GaAs DRAM

2.



(3)



BIBLIOGRAPHY

- Barnes, J.J., and J.Y. Chan, "A High Performance Sense Amplifier for a 5 V Dynamic RAM," *IEEE Journal of Solid-State Circuits*, vol. SC-15, no. 5, October 1980.
- Curtice, W.R., "A MESFET Model for Use in the Design of GaAs Integrated Circuits," *IEEE Transactions on Microwave Theory and Techniques*, vol. MTT-28, no. 5, May 1988.
- Dhong, S.H., N.C. Lu, W. Hwang, and S.A. Parke, "High-Speed Sensing Scheme for CMOS DRAM's," *IEEE Journal of Solid-State Circuits*, vol. 23, no. 1, February 1988.
- Fouts, D.J., "A Gallium-Arsenide Digital Phase Shifter for Clock and Control Signal Distribution in High-Speed Digital Systems," *IEEE Journal of Solid-State Circuits*, vol. 27, no. 5, pp. 802-809, May 1992.
- Fouts, D.J., and S.E. Butner, "Architecture and Design of a 500-MHz Gallium-Arsenide Processing Element for a Parallel Supercomputer," *IEEE Journal of Solid-State Circuits*, vol. 26, no. 9, pp. 1199-1211, September 1991.
- Hnatek, E.R., *A User's Handbook of Semiconductor Memories*, John Wiley & Sons, Inc., 1977.
- Nary, K.R., and S.I. Long, "GaAs Two-Phase Dynamic FET Logic: A Low Power Logic Family For VLSI," *IEEE Journal of Solid-State Circuits*, vol. 27, no. 10, pp. 1364-1371, October 1992.
- Pabst, J.W., T.E. Dungan, J.A. Cooper, Jr., and M.R. Melloch, "Ion-Implanted p-n Junction Capacitors for GaAs DRAM's," *IEEE Electron Device Letters*, vol. 37, no. 3, pp. 804-806, March 1990.
- Slater, M., *Microprocessor-Based Design, A Comprehensive Guide to Hardware Design*, pp. 200-214, Prentice-Hall, Inc., 1989.
- Starosel'skii, V.I., V.A. Bratov, and V.I. Suetinov, "Sense Amplifier for L.S.I. RAMs Based on Gallium Arsenide," *Soviet Microelectronics*, (Russian Original) vol.19, no. 4, pp. 208-213, July-August 1990. (translated) March 1991.
- Statz, H., P. Newman, I.W. Smith, R.A. Pucel, and H.A. Haus, "GaAs FET Device and Circuit Simulation in SPICE," *IEEE Transactions on Electron Devices*, vol. ED-34, no. 2, pp. 160-169, February 1987.
- Sussman-Fort, S.E., S. Narasimhan, and K. Mayaram, "A Complete GaAs MESFET Computer Model for SPICE," *IEEE Transactions on Microwave Theory and Techniques*, vol. 32, no. 4, April 1984.
- Tocci, R.J., *Digital Systems - Principles and Applications*, 3rd ed., pp.443-477, Prentice-Hall, Inc., 1985.
- Tannebaum, A.S., *Structured Computer Organization*, 2d ed., pp. 83-91, Prentice-Hall, Inc., 1984.
- Yuan, J.S., and J.J. Liou, "An Improved Latching Pulse Design for Dynamic Sense Amplifiers," *IEEE Journal of Solid-State Circuits*, vol. 25, no. 5, pp. 1294-1299, October 1990.

INITIAL DISTRIBUTION LIST

- | | | |
|----|---|---|
| 1. | Defense Technical Information Center
Cameron Station
Alexandria, VA 22304-6145 | 2 |
| 2. | Dudley Knox Library, Code 52
Naval Postgraduate School
Monterey, CA 93943 | 2 |
| 3. | Chairman, Code EC
Department of Electrical and Computer Engineering
Naval Postgraduate School
Monterey, CA 93943 | 1 |
| 4. | Douglas J. Fouts, Code EC/Fs
Department of Electrical and Computer Engineering
Naval Postgraduate School
Monterey, CA 93943 | 2 |
| 5. | Herschel H. Loomis, Jr., Code EC/Lm
Department of Electrical and Computer Engineering
Naval Postgraduate School
Monterey, CA 93943 | 2 |
| 6. | Michael A. Morris
Lieutenant, United States Navy
8930 Taurus Place
San Diego, CA 92126 | 4 |
| 7. | Christopher B. Vagts
Lieutenant Commander, United States Navy
927 Idaho Avenue
N. Charleston, SC 29404 | 1 |
| 8. | James B. Morris
18100 SW 55 Street
Ft. Lauderdale, FL 33331 | 1 |